

INSTALLATION RESTORATION PROGRAM

FINAL ABBREVIATED SITE INVESTIGATION SITES 3 AND 4

SECTIONS 1 - 8

158th FIGHTER WING
VERMONT AIR NATIONAL GUARD
SOUTH BURLINGTON, VERMONT

NOVEMBER 1996



HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs

Oak Ridge, Tennessee 37831-7606

managed by LOCKHEED MARTIN ENERGY SYSTEMS, INC.

for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

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**ABBREVIATED SITE INVESTIGATION REPORT
SITES 3 AND 4**

158th Fighter Wing
Vermont Air National Wing
South Burlington, Vermont

Submitted to:

**AIR NATIONAL GUARD READINESS CENTER
ANDREWS AIR FORCE BASE, MARYLAND**

Submitted by:

**HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
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NOVEMBER 1996

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VERMONT AIR NATIONAL GUARD
SOUTH BURLINGTON, VERMONT

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LIST OF ACRONYMS
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AMSL	above mean sea level
ANG	Air National Guard
ANGRC	Air National Guard Readiness Center
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CLP	Contract Laboratory Program
CME	Central Mining Equipment
CMP	Corrugated metal pipe
COC	chain of custody
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
DCE	Dichloroethene
DD	Decision Document
DI	deionized
DoD	Department of Defense
DOE	Department of Energy
DQO	data quality objective
EARTH TECH	The Earth Technology Corporation
EPA	United States Environmental Protection Agency
FCR	Field Change Request
FFS	Focused Feasibility Study
FID	flame ionization detector
FS	Feasibility Study
GC/MS	gas chromatograph/mass spectrometer
H & S	Health and Safety
HAZWRAP	Hazardous Waste Remedial Actions Program
HCl	hydrochloric acid
HMMD	Hazardous Materials Management Division

ID	inner diameter
IDW	investigation derived wastes
IRP	Installation Restoration Program
JP-4	Jet Propellant Number #4
LEL	lower explosivity level
mg/l	milligrams/liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAD	North American Datum
NCP	National Contingency Plan
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
O ₂	Oxygen
OD	outer diameter
OSWER	Office of Solid Waste and Emergency Response (EPA)
OVM	organic vapor meter
PA	Preliminary Assessment
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCE	tetrachlorethane
PES	Primary Enforcement Standard
pH	negative logarithm of hydrocarbon ion concentration
PID	Photoionization Detector
POL	Petroleum, oil, and lubricants
PP	polypropylene
PPAL	Primary Preventative Action Limit
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PQL	Practical Quantitation Limit
PVC	polyvinyl chloride
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference

SARA	Superfund Amendments and Reauthorization Act
SES	Secondary Enforcement Standard
SI	Site Investigation
SOV	Soil Organic Vapor
SVOC	Semivolatile Organic Compounds
TAL	Target Analyte List
TC	toxicity characteristic
TCA	Trichloroethane
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TD	total depth
TOC	top of casing
TPH	Total Petroleum Hydrocarbons
USCS	Unified Soil Classification System
UST	underground storage tank
VOC	Volatile Organic Compound
WMD	Waste Management Division

EXECUTIVE SUMMARY

This Abbreviated Site Investigation (ASI) Report presents the results of field investigation activities conducted by The Earth Technology Corporation (EARTH TECH) from August through October 1994 at Installation Restoration Program (IRP) Sites 3 and 4, located at Vermont Air National Guard (ANG) Base, South Burlington, Vermont, as requested by the Air National Guard Readiness Center. IRP Site 3 - Dry Well and nearby IRP Site 4 - Drainage Ditch Area are located in the north-central portion of the Vermont ANG Base, in the vicinity of the base petroleum, oil, and lubricants (POL) facility, and south of the northern base boundary adjacent to Poor Farm Road. Site 3 consists of an abandoned dry well located adjacent to the west wall of the transfer pump house (Building 205) at the base POL facility. Reportedly, as much as 20,000 gallons of Jet Propellant Number 4 (JP-4) fuel were discharged to the dry well from 1954 to 1984. Site 4 consists of a covered and open drainage ditch area, located immediately south of Poor Farm Road along the northern base boundary, northeast of Site 3. Excavation above the dry well in 1986 indicated JP-4 fuel contaminated soil. Prior to 1981, the ditch received surface water run-off from the flightline and parking apron areas, which periodically included fuel spills. A 2,000 gallon spill of JP-4 fuel at the POL facility in 1967 was the largest documented spill which drained into the ditch. Excavation for sanitary sewer lines in the western (covered) portion of the ditch in 1988 revealed JP-4 fuel contaminated soil.

ASI field investigation activities consisted of field screening and confirmation activities designed to enable confirmation of suspected fuel JP-4 related contamination. The ASI field work was performed in conjunction with ongoing Supplemental Remedial Investigation (SRI) field investigation activities for IRP Sites 1 and 2. The proposed field program for the ASI field activities was presented in the ASI Work Plan (EARTH TECH 1994b), and supported by the SRI Sampling and Analysis Plan (EARTH TECH 1994c).

Field screening activities primarily consisted of soil organic vapor surveys and groundwater screening, which utilized on-site gas chromatograph analysis for target volatile organic compounds (VOCs). Field screening results supported implementation of confirmation activities. Confirmation activities primarily consisted of drilling and subsurface soil sampling, monitoring well installation, well development, groundwater sampling, surface water and sediment sampling, water level and free-product measurement, and laboratory analyses. Laboratory analyses of submitted environmental samples included analysis for organics; VOCs, semivolatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPH); and inorganics; Target Analyte List metals.

Background Results

Laboratory analytical results for subsurface soil and groundwater samples from single background locations in Site 3 and Site 4 indicated no organic or inorganic contamination. Groundwater concentrations of iron and manganese exceed State of Vermont Secondary Enforcement Standards in all SRI and ASI background wells, and in all Site 3 and Site 4 wells; however, these concentrations are not site related and are likely related to local geologic/hydrogeologic conditions.

Site 3 Contamination

Laboratory analytical results for subsurface soil and groundwater samples from Site 3 indicate the following site related contamination.

Organic soil contamination was indicated in Site 3 in the immediate vicinity (generally within 50 ft) of the dry well and transfer pump house (Building 205). Subsurface soil contamination was predominantly indicated in three of five soil borings, from depths ranging from shallow (3 to 5 ft bgs) to intermediate (8 to 15 ft bgs). The highest concentrations of organic contaminants were indicated proximal to the water table in the 13 to 15 ft sample interval in one boring. Significant soil contamination included: concentrations of VOCs in excess of State of Vermont Residual Soil Values (benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, styrene, toluene, and total xylenes), SVOCs in concentrations exceeding 1 part per million (ppm) (2-methynaphthalene, naphthalene, and bis(2-ethylhexyl)phthalate), and TPH in concentrations exceeding 1 ppm.

Organic, and possibly inorganic, groundwater contamination was indicated in Site 3, in an area immediately hydraulically downgradient of the dry well and the pump house (Building 205). Free-product (JP-4 fuel) was measured in one of three site monitoring wells, and that well was not sampled. Significant organic groundwater contamination was indicated in one of two site wells sampled, and included VOCs (benzene, ethylbenzene, and total xylenes) in excess of State of Vermont Groundwater Quality Standards and TPH in concentrations exceeding 1 ppm. Possible inorganic groundwater contamination was limited to detections of lead which exceeded the State of Vermont Groundwater Quality Standard in both site wells.

Site 4 Contamination

Laboratory analytical results for subsurface soil, groundwater, surface water, and surface sediment samples from Site 4 indicate the following site related contamination.

Organic soil contamination was indicated near the water table in the western portion of Site 4, in the vicinity (generally within 50 ft) of the initial sewer line excavation. Subsurface soil contamination was limited to sample depths near the water table (17 to 19 ft bgs) in three of six soil borings. The highest concentrations of organic contaminants were indicated in two borings located closest to the initial sewer line excavation. Significant soil contamination included concentrations of VOCs in excess of State of Vermont Residual Soil Values (benzene, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, styrene, and total xylenes), SVOCs in concentrations exceeding 1 ppm (methynaphthalene and naphthalene), and TPH in concentrations exceeding 1 ppm.

Organic, and possibly inorganic, groundwater contamination is present in Site 4. Free-product (JP-4 fuel) was detected in one of three site monitoring wells, and that well was not sampled. Significant organic groundwater contamination was indicated in the western portion of Site 4, in one monitoring well. Detections included VOCs (benzenes and total xylenes) in excess of State of Vermont Groundwater Quality Standards, and a TPH concentration in excess of 1 ppm. Possible inorganic groundwater contamination was indicated in the western and eastern portions of Site 4, and included: detections of lead in two wells in excess of the State of Vermont Groundwater Quality Standards, a detection of arsenic in one well in excess of the

Groundwater Quality Standard, and a detection of chromium in one well in excess of the State of Vermont Quality Standard.

Hydrogeologic and analytical data indicate probable off-base migration of Site 4 groundwater contamination. Groundwater is apparently migrating to the northeast, across the base boundary and Poor Farm Road toward privately owned property (the Griswold property).

Organic surface water and sediment contamination is present in the open drainage ditch in the eastern portion of Site 4. Organic contamination was limited to detections of TPH in the ppm range in the one surface water sample and in all three surface sediment samples.

Recommendations

The conclusions based on the results of ASI field investigation activities conducted at IRP Sites 3 and 4, support the following recommendations.

- Groundwater is the primary contamination concern in Sites 3 and 4. The most significant soil contamination is located at or proximal to (within 5 ft) the water table. Additional ASI field screening and confirmation activities should be conducted to determine the horizontal extent, particularly the off-base extent, of free-product and dissolved-phase groundwater contamination. The results of these activities will enable development of the interim remedial actions listed below.
 - Interim remedial actions should be developed and implemented to intercept the off-base migration of dissolved-phase organic (and possibly inorganic) groundwater contamination.
 - Interim remedial actions should also be developed and implemented to abate the extent of free-product, in Site 3 and 4 and prevent its off-base migration in the vicinity of Site 4 and Poor Farm Road.
- Longer term remedial actions for Sites 3 and 4 should be focused on areas of free-product and groundwater contamination, particularly in source areas and off-base areas.
 - Remedial actions for shallow to intermediate subsurface soil contamination (above depths proximal to the water table), if required, should be limited to the dry well and transfer pump house (Building 205) area in Site 3 and possibly the initial sewer line excavation area in the Site 4.
- In conjunction with selected remedial actions, additional data may be developed to enable 1) further delineation of the nature and extent of on-base and off-base soil and groundwater contamination (vertical and horizontal extent), and 2) further characterization of local geologic and hydrogeologic conditions.

1.0 INTRODUCTION

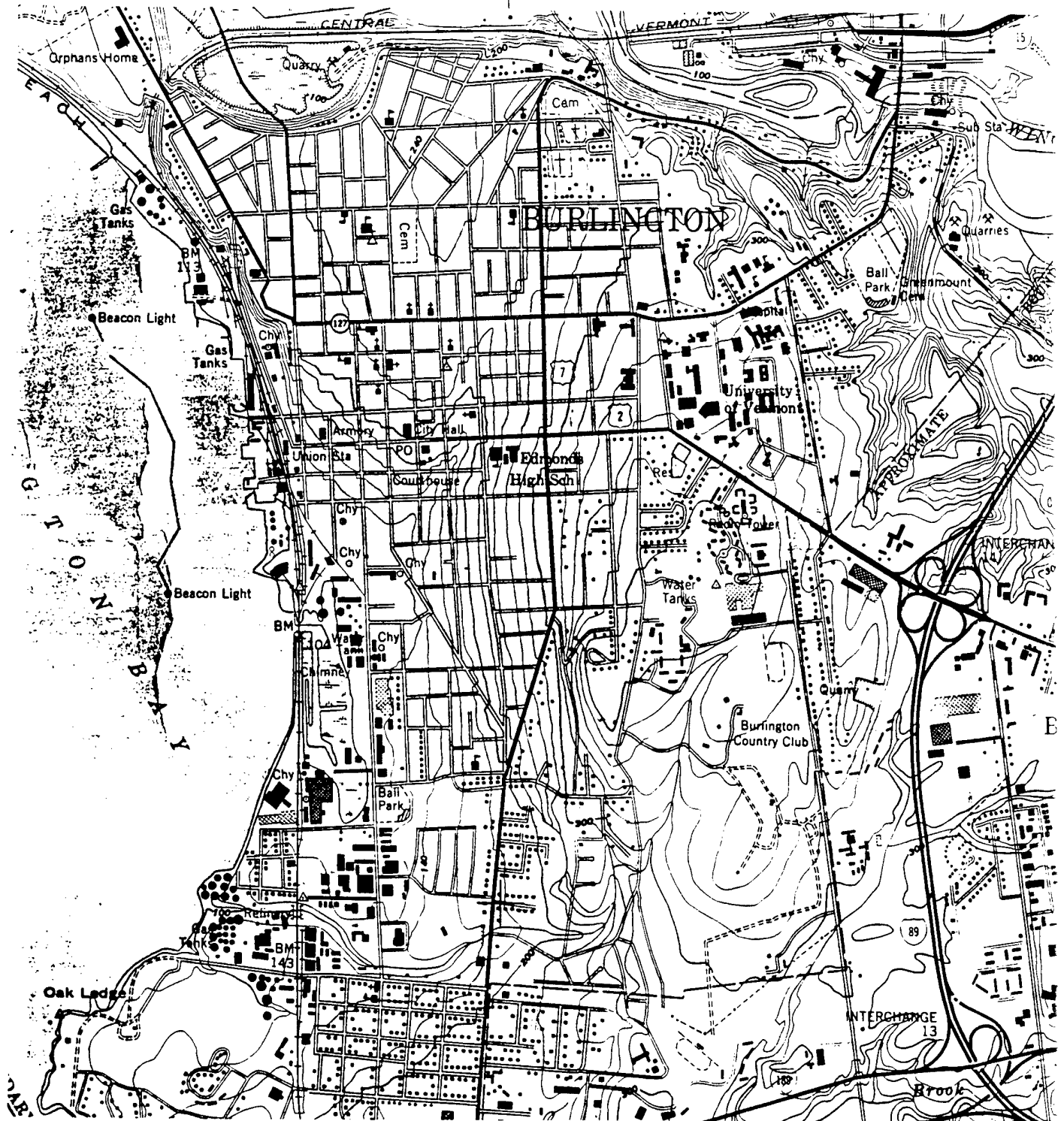
This report documents the Abbreviated Site Investigation (ASI) activities that The Earth Technology Corporation (EARTH TECH) performed at Installation Restoration Program (IRP) Sites 3 and 4 at Vermont Air National Guard (ANG) Base, South Burlington, Vermont (Figure 1-1), under the United States (U.S.) Department of Defense (DOD) IRP. ASI activities were conducted from August 1994 through October 1994, in accordance with the ASI Work Plan (WP) (EARTH TECH 1994b) and the Supplemental Remedial Investigation (SRI) Sampling and Analysis Plan (SAP) (EARTH TECH 1994c). Support information regarding general facility background, previous facility investigations, and environmental setting is presented in the SRI WP (EARTH TECH 1994a).

1.1 PURPOSE OF THE INSTALLATION RESTORATION PROGRAM

The DOD initiated the IRP to identify, evaluate, and remediate suspected environmental problems associated with past usage, storage, handling, and disposal of hazardous substances at DOD facilities. Section 120 of the Superfund Amendments and Reauthorization Act (SARA) of 1986 requires that IRP activities adhere to procedures specified in the National Oil and Hazardous Substances Contingency Plan (NCP) Final Rule; 55 Code of Federal Regulations 8666. The NCP details a sequence of steps to be followed when investigating and cleaning up suspected hazardous waste sites. This sequence begins with the discovery of a suspected hazardous waste release or threat of release, and ends with a permanent remedy to eliminate or minimize the environmental impact and long-term monitoring of the remediation effort. The five phases that constitute the IRP process and the purpose and activities associated with each phase are presented below:

- **Preliminary Assessment** – A Preliminary Assessment (PA) is performed to identify the location of suspected problems associated with past hazardous waste handling procedures, disposal sites, and spill sites. This is accomplished through interviews with past and present base employees, historical records searches, and visual site inspections. Detailed geologic, hydrogeologic, meteorologic, land use, and environmental data for the area of study are also gathered. A detailed analysis of all information obtained identifies sites of concern.
- **Site Investigation** – The purpose of an Site Investigation (SI) or an ASI is to acquire the necessary data to either confirm or deny the existence of contamination at each identified site of concern. The SI or ASI includes identifying specific chemical contaminants and their concentrations in environmental media and determining the potential for contaminant migration through site-specific hydrogeologic investigations.
- **Remedial Investigation** – During an RI, necessary data are acquired to define the extent of confirmed contamination and to further assess the associated potential risks to human health, welfare, or the environment. The RI quantifies the magnitude and extent of contamination at the sites under investigation and

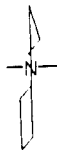
LONGITUDE 73° 12' 30"



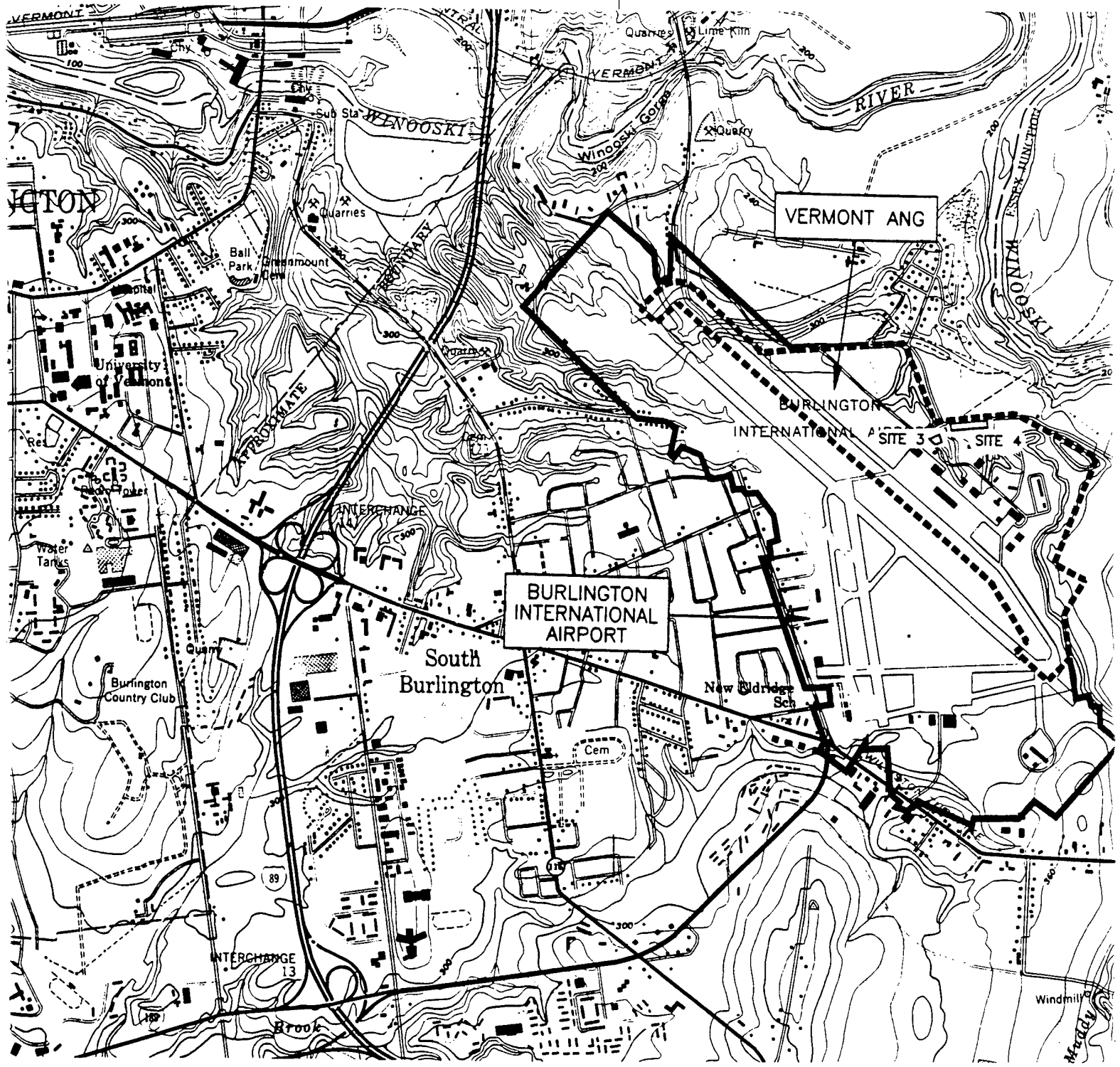
"BURLINGTON QUADRANGLE, VERMONT-CHITTENDEN COUNTY,
7.5 MINUTE SERIES (TOPOGRAPHIC)."
UNITED STATES GEOLOGICAL SURVEY, 1948, PHOTOREVISED 1987

1000 0 1000 2000 3000 4000 5000 6000
SCALE

TOPOGRAPHIC CONTOUR INTERVAL 10 FEET (Above Mean Sea Level)
NATIONAL GEODETIC VERTICAL DATUM OF 1929



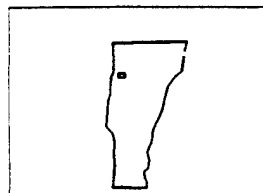
LONGITUDE 73° 10'



1000 2000 3000 4000 5000 6000 7000 FEET

TOPOGRAPHIC CONTOUR INTERVAL 10 FEET (Above Mean Sea Level)
NATIONAL GEODETIC VERTICAL DATUM OF 1929

LOCATION



VERMONT AIR NATIONAL
GUARD (ANG) BASE
BOUNDARY

BURLINGTON INTERNATIONAL
AIRPORT BOUNDARY

INSTALLATION RESTORATION
PROGRAM SITE BOUNDARY
(SITES 1 AND 2)

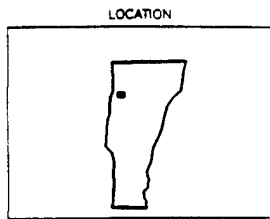
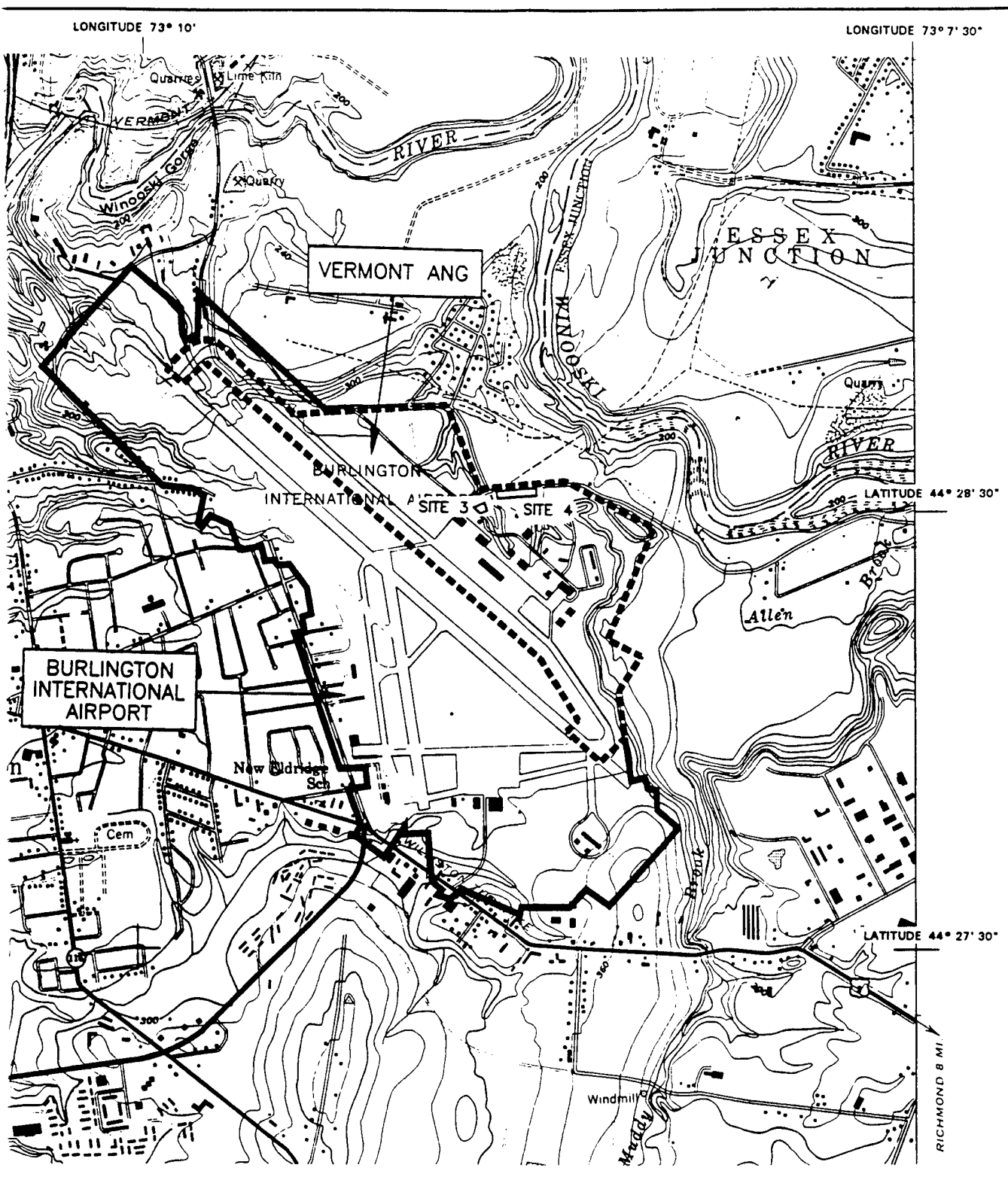
EARTH 

GEN
VI

SOUTH

JANUARY 1996

2



- VERMONT AIR NATIONAL GUARD (ANG) BASE BOUNDARY
- BURLINGTON INTERNATIONAL AIRPORT BOUNDARY
- INSTALLATION RESTORATION PROGRAM SITE BOUNDARY (SITES 1 AND 2)

EARTH TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER GROUP
SOUTH BURLINGTON, VERMONT

GENERAL LOCATION MAP OF
VERMONT AIR NATIONAL
GUARD BASE
SOUTH BURLINGTON, VERMONT

JANUARY 1996

FIGURE 1-1

3

identifies the specific chemical contaminants present and their concentrations in environmental media. A determination also is made as to the potential for contaminant migration by assessing site-specific hydrogeologic and contaminant characteristics.

- **Feasibility Study** – An FS is performed to develop the remedial action alternative that mitigates confirmed environmental contamination at each site and meets applicable or relevant and appropriate requirements (ARARs). The FS considers risk assessments and cost benefits analyses in providing the necessary data, direction, and documented supportive rationale to acquire regulatory concurrence (federal, state, and local) with the recommended remedial alternative. During the FS, recommendations are evaluated, developed, and provided for remedial actions at each site where remediation is required.
- **Remedial Design** – The purpose of Remedial Design (RD) is to provide engineering design drawings and construction specifications required to implement the recommended remedial action selected through the FS process.
- **Remedial Action** – The Remedial Action (RA) is the implementation of the RD. A RA plan requires appropriate regulatory acceptance prior to implementation.

The IRP requires the identification and evaluation of environmentally deleterious sites on DOD installations and the control of adverse effects on human health or the environment from those sites. The ANG Readiness Center (ANGRC), through a U.S. Air Force interagency technical support agreement with the U.S. Department of Energy (DOE), uses Lockheed Martin Energy Systems, Inc. (Energy Systems) to provide technical assistance for the implementation of the ANG IRP. EARTH TECH has been retained by Energy Systems under the Hazardous Waste Remedial Actions Program (HAZWRAP) to conduct the ASI at the Vermont ANG Base.

1.2 PURPOSE OF THE ABBREVIATED SITE INVESTIGATION

This ASI was conducted to determine whether environmental contamination is present at Vermont ANG Base and to characterize the nature of any identified contamination. Contaminated sites may require additional field investigative efforts to characterize completely the magnitude and extent of any confirmed contamination. The objectives of the ASI at Vermont ANG Base were as follows:

- Determine the chemical nature and magnitude of identified contaminants
- Evaluate the potential for contaminant release and migration
- Prepare recommendations for broader investigative activities to determine the magnitude and extent of contamination, if necessary
- Evaluate the need for immediate response actions

- Support no further action decisions and the completion of Decision Documents (DD) if appropriate.

1.3 REPORT ORGANIZATION

This ASI report contains the following eight text sections:

- **Section 1.0 Introduction** – The remainder of this section summarizes the purpose of the IRP and ASI, and presents the ASI report organization and previous IRP program activities.
- **Section 2.0 Facility Background** – This section presents descriptions of Vermont ANG Base and IRP Sites 3 - Dry Well and Site 4 - Drainage Ditch Area.
- **Section 3.0 Environmental Setting** – This section presents local and regional environmental settings.
- **Section 4.0 Field Program** – This section describes the activities, methods, and procedures used for determining the presence or absence of environmental contamination and the geologic/hydrogeologic conditions at IRP Sites 3 and 4, including background and site area sampling and the disposal investigation derived wastes. Significant changes from proposed work plan activities and the field work performed are also discussed.
- **Section 5.0 Field Investigation Results** – This section provides the geologic/hydrogeologic and field and laboratory analytical results obtained during the ASI program, along with the significance of the results.
- **Section 6.0 Conclusions** – This section presents site-specific conclusions based on the ASI findings.
- **Section 7.0 Recommendations** – This section present site-specific recommendations for future IRP activities at Sites 3 and 4.
- **Section 8.0 Bibliography** - This section provides the references noted in the report.

A list of acronyms and abbreviations is also included in this ASI report. A separate appendix volume (Appendices A through K) is provided, and contains in the following order: Appendix A - Field Change Request (FCR) Forms, Appendix B - Field Screening Data (soil organic vapor (SOV) and groundwater screening survey results), Appendix C - Field Logs (soil boring logs, monitoring well installation logs, monitoring well development logs, monitoring well purge logs, monitoring well sampling logs, surface water sampling logs, and surface sediment sampling logs), Appendix D - Survey Data, Appendix E - State of Vermont Split Sample Analytical Data, Appendix F - Investigation Derived Waste Characterization Data, Appendix G - Applicable or Relevant and Appropriate Requirements, Appendix H - Laboratory Analytical Data Quality, Appendix I - Data Validation Summaries, Appendix J - Laboratory

Analytical Data and Chain of Custody (COC) Forms, and Appendix K - Base-wide Background Laboratory Analytical Results for Inorganics in Soils and Groundwater.

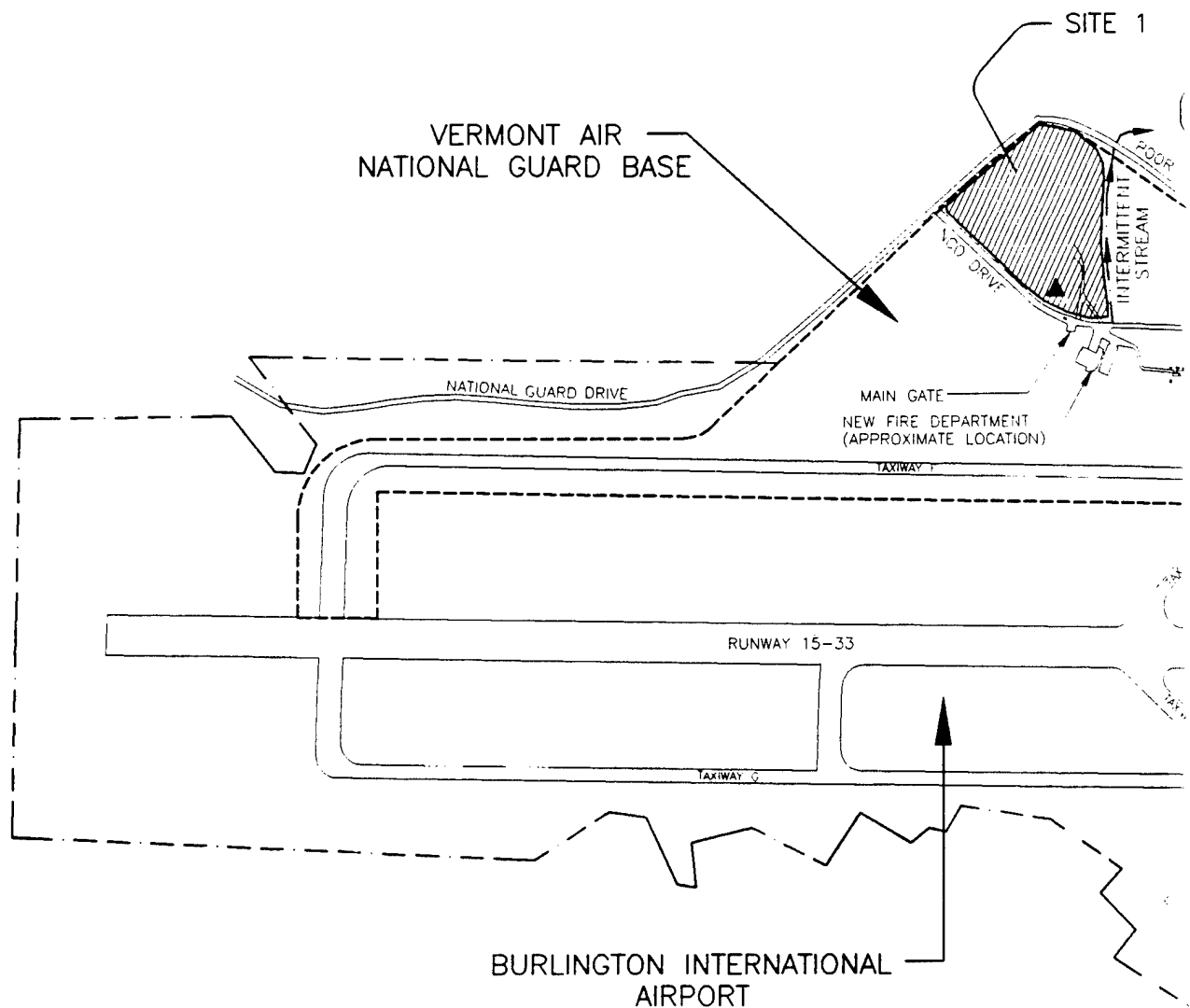
1.4 PREVIOUS PROGRAM ACTIVITIES

Previous IRP activities at Vermont ANG Base have been focused on IRP Sites 1 and 2. No previous IRP studies had been conducted at IRP Sites 3 and 4. Sites 1 and 2 are located in the northwest and southeast portions of the base, respectively. Sites 3 and 4 are located in the north-central portion of the base. IRP site locations are shown on the base map presented in Figure 1-2. Previous IRP activities at the base are summarized in the following discussion.

A base-wide PA was conducted in 1983 by CH₂M Hill (CH₂M Hill 1983). The PA identified IRP Sites 1 and 2 (Site 1 Fire Training Area/ Old Landfill and Site 2 Construction Rubble Landfill). The PA also identified past and current operations at the base petroleum, oil, lubricant (POL) facility and the flightline area. Although IRP Sites 3 and 4 were not identified in the PA, some information regarding POL facility and flightline area operations was presented which is pertinent to current conditions at IRP Sites 3 and 4.

In 1986, Roy F. Weston, Incorporated (Weston) conducted a Phase II Problem Confirmation/Quantification Stage 1 Study, equivalent to an SI, at IRP Sites 1 and 2. The Phase II Stage 1 report confirmed and further characterized site-specific contamination at these sites (Weston 1986).

An RI was conducted at IRP Sites 1 and 2 from 1988 to 1989 by Earth Technology Corporation (Earth Technology). In May 1991, the RI/FS Report was completed by Earth Technology for IRP Sites 1 and 2 (Earth Technology 1991). At this time, the RI/FS Report was submitted to the Vermont Hazardous Materials Management Division (HMMD) for review. In November 1992, a regulatory meeting was held to discuss Vermont HMMD's review comments on the RI/FS Report and to address various data gaps identified within the report. At this meeting ANGRC personnel notified HAZWRAP and Earth Technology Corporation personnel of two additional IRP sites that required investigation; Site 3 - Dry Well and Site 4 - Drainage Ditch Area. Identification of these sites was based on information provided by Vermont ANG Base personnel. Fuel related soil contamination had been noted at the two sites during various base construction and investigative activities.



LEGEND:



APPROXIMATE LOCATION OF INSTALLATION RESTORATION PROGRAM SITE (SITES 1 THROUGH 4)



LOCATION OF IRP SITE BACKGROUND BORINGS/MONITORING WELLS (SITE 1 - V1-BR4, SITE 2 - V2-BG1, SITE 3 - V3-BG1, AND SITE 4 - V4-BG1) AND MONITORING WELLS (SITE 1 - V1-RFW1 AND V1-RFW1A)



VERMONT AIR NATIONAL GUARD BASE BASE BOUNDARY



BURLINGTON INTERNATIONAL AIRPORT BOUNDARY



PAVED AREA (ROAD, RUNWAY, ETC.)



BUILDINGS



ABOVEGROUND STORAGE TANK



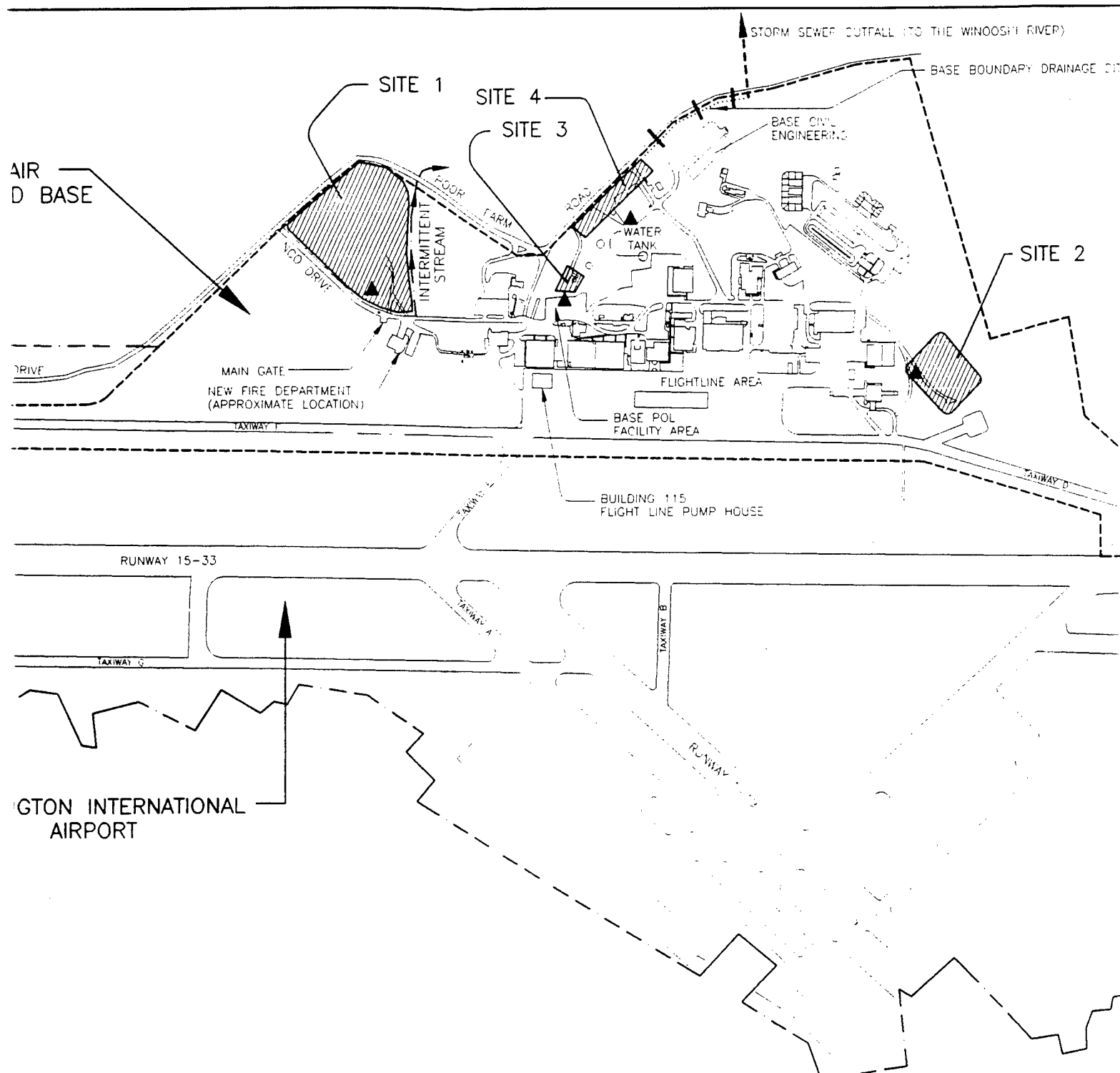
PETROLEUM, OIL, LUBRICANTS



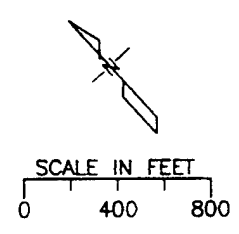
STEEL SHEETPILE WIER (IN BASE BOUNDARY DRAINAGE DITCH)



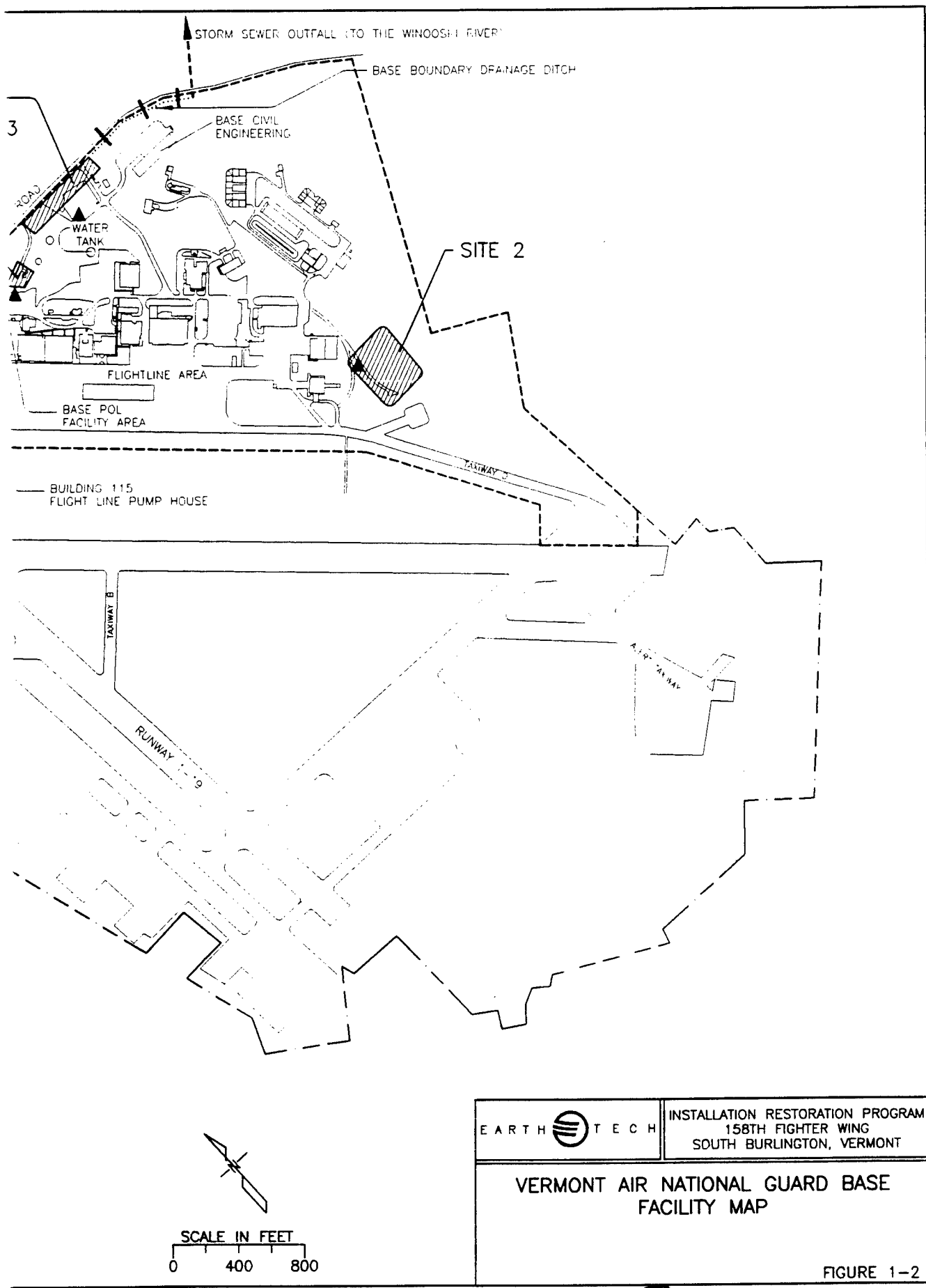
SUBSURFACE 48-INCH CORRUGATED METAL PIPE (EXTENDS FROM BASE BOUNDARY DRAINAGE DITCH TO WINOOSKI RIVER)



- BUILDINGS
- ABOVEGROUND STORAGE TANK
- PETROLEUM, OIL, LUBRICANTS
- STEEL SHEETPILE WIER (IN BASE BOUNDARY DRAINAGE DITCH)
- SUBSURFACE 48-INCH CORRUGATED METAL PIPE
(EXTENDS FROM BASE BOUNDARY DRAINAGE DITCH
TO WINOOSKI RIVER)



EARTH
VERM



3

2.0 FACILITY BACKGROUND

Descriptions of Vermont ANG Base and IRP Sites 3 and 4 are presented in the following sections.

2.1 Facility Description

Vermont ANG Base is located in western Chittenden County, Vermont, immediately northeast of the Burlington International Airport in the city of South Burlington and approximately 3.5 miles east of Lake Champlain (Figure 1-1). The base encompasses approximately 223 acres. The city limit of Burlington, Vermont, located on the eastern shore of Lake Champlain, is located approximately 1.5 miles east of the base.

The base was first organized in 1946. Previous operations have primarily been focused on the operation and maintenance of various fighter wing aircraft. The current principal mission of Vermont ANG Base is to support and maintain the 158th Tactical Fighter Wing, its aircraft (primarily F-16 fighter jets), crew, support personnel, vehicles, and equipment.

2.2 Site Descriptions

IRP Sites 3 and 4, located in the north-central portion of Vermont ANG Base, are south of the northern base boundary adjacent to Poor Farm Road (Figures 1-2 and 2-1). A general description of each site is presented in the following sections.

2.2.1 Site 3 - Dry Well

Site 3 consists of an abandoned dry well located adjacent to the southwest wall of the transfer pump house (Building 205) at the base POL facility (Figure 2-1). According to Vermont ANG Base, the dry well is located approximately 4 ft below ground surface (bgs), and measures 3 ft square by 8 ft deep, with walls consisting of approximately 4 to 8 inches of cobblestones covered by 2-inch thick wooden planks. The top of the dry well is covered by wood planking and possibly other material. The dry well was connected to the floor of Building 205 by a subsurface drainpipe. An attempt by base personnel to locate the top of the dry well in 1986 was aborted when a strong fuel odor was noted during shallow excavation activities. In 1988, the drainpipe leading from the floor of Building 205 to the dry well was plugged with concrete.

Reportedly, previous fuel system maintenance in Building 205 included the periodic release of 300 to 400 gallons of JP-4 fuel from the system separator when changing fuel system filters. The fuel was reportedly released to the floor drain which discharged to the dry well. This maintenance activity occurred approximately every three years from 1954 to 1984. Base personnel estimate as much as 20,000 gallons of fuel may have been cumulatively discharged to the dry well.

SITE 4

GRISWOLD PROPERTY

POOR FARM ROAD (GRAVEL)

BASE BOUNDARY

GRAVEL

SITE 3

FORMERLY
AST
201

FORMERLY
AST
200

GRAVEL

ROAD

AST
202

205

FUEL TRANSFER
PUMP HOUSE

DRY WELL

ASPHALT
PARKING LOT

LEGEND:



FENCE



VERMONT AIR NATIONAL GUARD
BASE BOUNDARY



GRASS



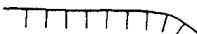
TREES



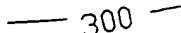
BUILDING AND BASE
NUMBER



ABOVEGROUND STORAGE TANK
AND BASE NUMBER



EARTHEN BERM
(TICK MARKS ON DEPRESSION SIDE)



TOPOGRAPHIC CONTOUR IN FEET ABOVE MEAN SEA LEVEL
(DATA FROM BASE SURVEY)
(CONTOUR INTERVAL - 10 FEET)

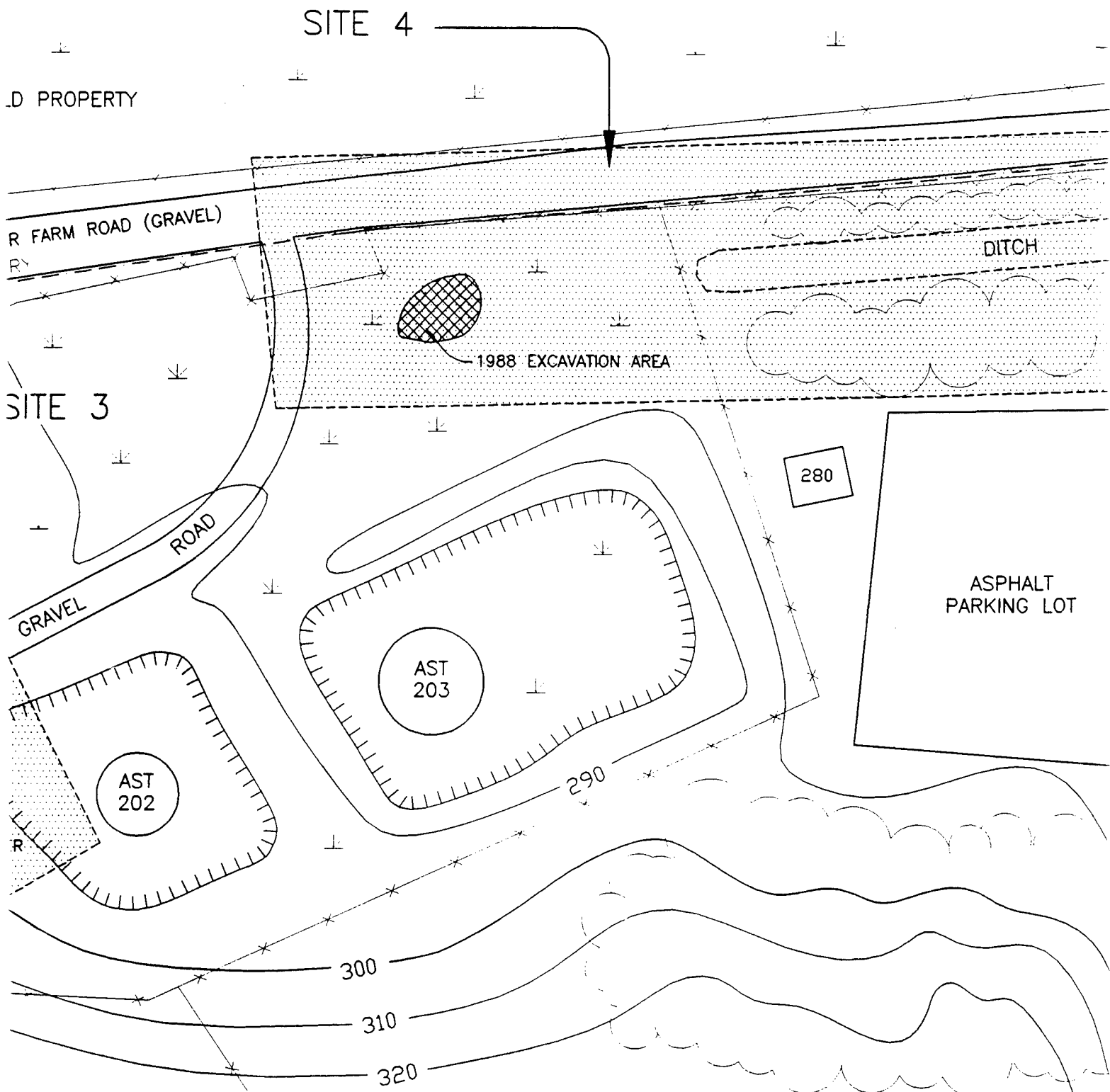


APPROXIMATE INSTALLATION RESTORATION
PROGRAM SITE BOUNDARY

300

310

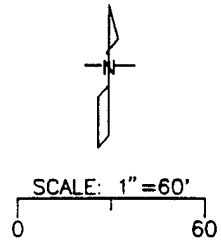
320



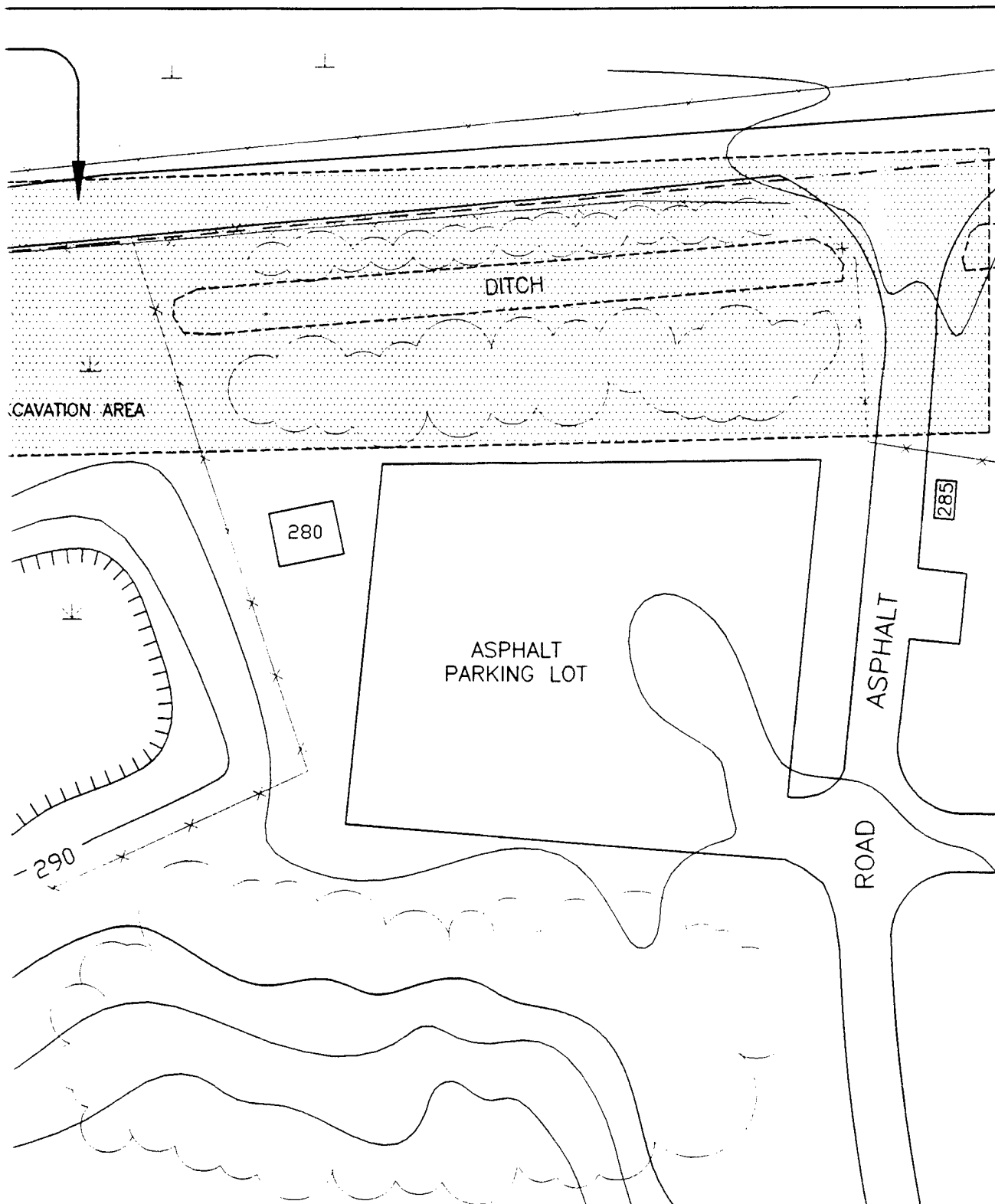
1/4" BERM
MARKS ON DEPRESSION SIDE)

GRAPHIC CONTOUR IN FEET ABOVE MEAN SEA LEVEL
(FROM BASE SURVEY)
TOUR INTERVAL - 10 FEET)

OXIMATE INSTALLATION RESTORATION
RAM SITE BOUNDARY



EARTH
AREA



EARTH  TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
BURLINGTON, VERMONT

SITES 3 AND 4
AREA SITE PLAN AND TOPOGRAPHY

FIGURE 2-1

3

The POL facility includes the aboveground storage tank (AST) farm located adjacent to Building 205 (Figure 2-1). Prior to 1991, the AST farm consisted of four tanks (AST Numbers 200 through 203) connected by underground piping to Building 205 (Figure 2-1). The four ASTs held jet propellant (JP) Number 4 (JP-4) fuel for the operation of various aircraft. The tanks varied in size; AST 200 - 110,251 gallons, AST 201 - 214,704 gallons, AST 202 - 216,075 gallons, and AST 203 - 419,431 gallons. Upon shipment to the base, fuel was transferred via underground piping from the POL facility truck off-loading station to Building 205, which then transferred it to any of the four ASTs for storage. Subsequently, fuel was pumped from the ASTs through Building 205 to either the POL facility truck fillstand or to the flightline pump house (Building 115) (Figure 1-2). In 1991, all four ASTs were emptied of JP-4 fuel. In the summer of 1994, ASTs 200 and 201, and associated underground piping, were dismantled and removed. Since 1994, ASTs 202 and 203 and associated underground piping have been utilized for receiving and storage of JP-8 fuel.

2.2.2 Site 4 - Drainage Ditch Area

Site 4 consists of covered and open drainage ditch areas, located immediately south of Poor Farm Road along the northern base boundary (Figure 2-1). Poor Farm Road is bounded to the north by privately owned property (the Griswold property). The covered drainage ditch area is located in the western portion of Site 4. The open drainage ditch is located in the eastern portion. The western portion of the ditch area was formerly an open drainage ditch but is currently underlain by various subsurface storm and sanitary sewer piping. Surface drainage from POL facility areas and the flightline and parking apron areas, located south and southeast of Site 4, are transmitted to the western portion of Site 4 via subsurface piping. Drainage is then directed into a single corrugated metal pipe (CMP), which connects to the open ditch. Surface water transmitted to the eastern portion of Site 4 continues eastward in the open ditch and eventually feeds into a CMP which exits the base beneath Poor Farm Road (Figure 1-2). Surface water flow in the vicinity of Sites 3 and 4 is discussed further in Section 1.6.3.

The Site 4 drainage ditch area has historically received surface water run-off from the aforementioned base areas, from open drainage ditches and/or subsurface piping, typically located around 5-10 ft bgs. Prior to 1981, standard base practice consisted of washing spilled fuel from the flightline and parking apron into catch basins, which discharged into open drainage ditches that extended northward and eventually fed into the aforementioned ditch. The drainage ditches have since been replaced by subsurface storm sewer piping systems. The PA (CH₂M Hill 1983) noted that historic fuel spills were small, except for one spill of approximately 2,000 gallons of JP-4 fuel in 1967. The fuel was reportedly spilled from the POL facility truck off-loading station on NCO Drive (located in the base POL facility area presented in Figure 1-2) and drained down stormwater drainage ditches to a sheetpile dam (Figure 1-2) in the base boundary drainage ditch located east of Site 4 (Figure 1-2). The PA (CH₂M Hill 1983) also noted no actions were taken to recover the spilled fuel. Currently, fuel spills on the flightline or POL areas are contained locally and not transmitted through the storm drainage system.

In 1988, excavation of soil during the installation of subsurface sanitary sewer facilities in the western portion of the Site 4 revealed the presence of hydrocarbon impacted soil. The general area of the excavation is indicated in Figure 2-1. The impacted soil, excavated from beneath

a subsurface storm sewer (CMP), yielded a strong fuel odor. The CMP was breached during excavation releasing some standing water to the excavated area. No visible hydrocarbon product or hydrocarbon odor was noted in the released standing water. The breached CMP was subsequently repaired, and the excavation was backfilled upon completion of sanitary sewer construction activity.

3.0 ENVIRONMENTAL SETTING

The regional and local environmental settings for the Vermont ANG Base area physiography and topography, climate, surface water hydrology, and regional and local geologic and hydrogeologic settings are presented in the following sections.

3.1 Physiography and Topography

Western Chittenden County, Vermont is located in the Champlain Lowland Physiographic Province (Champlain Lowland) (Stewart and MacClintock 1969) (Figure 3-1). The Champlain Lowland consists of a north to south trending structural trough between the Green Mountains of Vermont to the east and the Adirondack Mountains of New York to the west (Stewart and MacClintock 1969). The Champlain Lowland is also bounded by the Taconic Mountains to the southeast. The width of the Champlain Lowland generally ranges from 12 to 15 miles (USDA 1989). The development of the Champlain Lowland and adjacent physiographic areas was principally due to regional structural geologic processes, and to a lesser extent, glacial, marine, and alluvial processes. Lake Champlain, a regional fresh water lake, occupies the western portion of the province, extending for approximately 120 miles along the New York-Vermont border and into Quebec Province, Canada. The lowland area in the vicinity of the lake is referred to as the Champlain Valley. The lake features depths ranging from a mean of 40 ft to a maximum of 400 ft, and a maximum width of 12 miles in the vicinity of the city of Burlington. Western Chittenden County is characterized by low topographic relief and isolated hills. Deltaic lowlands are located around the periphery of Lake Champlain. The elevation along the shoreline of the lake is in the vicinity of 95 ft above mean sea level (AMSL) (USGS 1987). Lowland elevations generally range from 200 ft to 400 ft AMSL, with elevations increasing away from the lake (USGS 1987). Much of the lowland area topography resulted from recent glacial, marine, or alluvial processes. The occurrence of isolated hills increases eastward with proximity to the Green Mountains, with elevations generally ranging from 600 ft to 700 ft AMSL (USDA 1989). Significant hills within the Champlain Lowland are commonly the result of geologic faulting. Summit elevations of the Green Mountains generally range from 2,000 ft to greater than 4,000 ft AMSL (Stewart and MacClintock 1969).

Vermont ANG Base is situated on a broad alluvial terrace above the Winooski River Valley in the Champlain Lowland Province, approximately three miles west of the foothills of the Green Mountains. Elevations over most of the base range between 320 ft and 340 ft AMSL. A northward-eastward sloping alluvial escarpment featuring less than 20 ft to greater than 80 ft of topographic relief is present along the north-northeast boundary of the base. The topography of this boundary area subsequently slopes northward-eastward toward the southern bank of the Winooski River, which features an elevation in the vicinity of 195 ft AMSL (USGS 1987) (Figure 1-1). Most of the base facilities and the flightline area are located topographically up-gradient of the escarpment. IRP Sites 3 and 4 are located topographically down-gradient of the escarpment. Elevations at IRP Site 3 range between 295 ft and 300 ft AMSL (Figure 2-1). Elevations at IRP Site 4 range between 280 ft and 290 ft AMSL (Figure 2-1).

3.2 Climate

Climatological data, unless otherwise noted, are summarized from information presented by the National Oceanic and Atmospheric Administration (NOAA) for the Burlington, Vermont area from 1958 through 1987 (NOAA 1987).

The northerly latitude of the Burlington, Vermont area gives it a typical New England climate, characterized by moderately warm summers and cold winters. The coldest temperatures, in winter months, are typically caused by high pressure systems originating from central Canada or the Hudson Bay. Average monthly temperatures have ranged from 17.7°F in January to 69.8°F in July. Minimum daily winter temperatures are commonly greater than 10°F, and maximum daily summer temperatures commonly range from 70 to 90°F. Locations proximal to Lake Champlain typically experience moderated temperatures, particularly in winter months when lake effect heating can increase local temperatures 5 to 10°F.

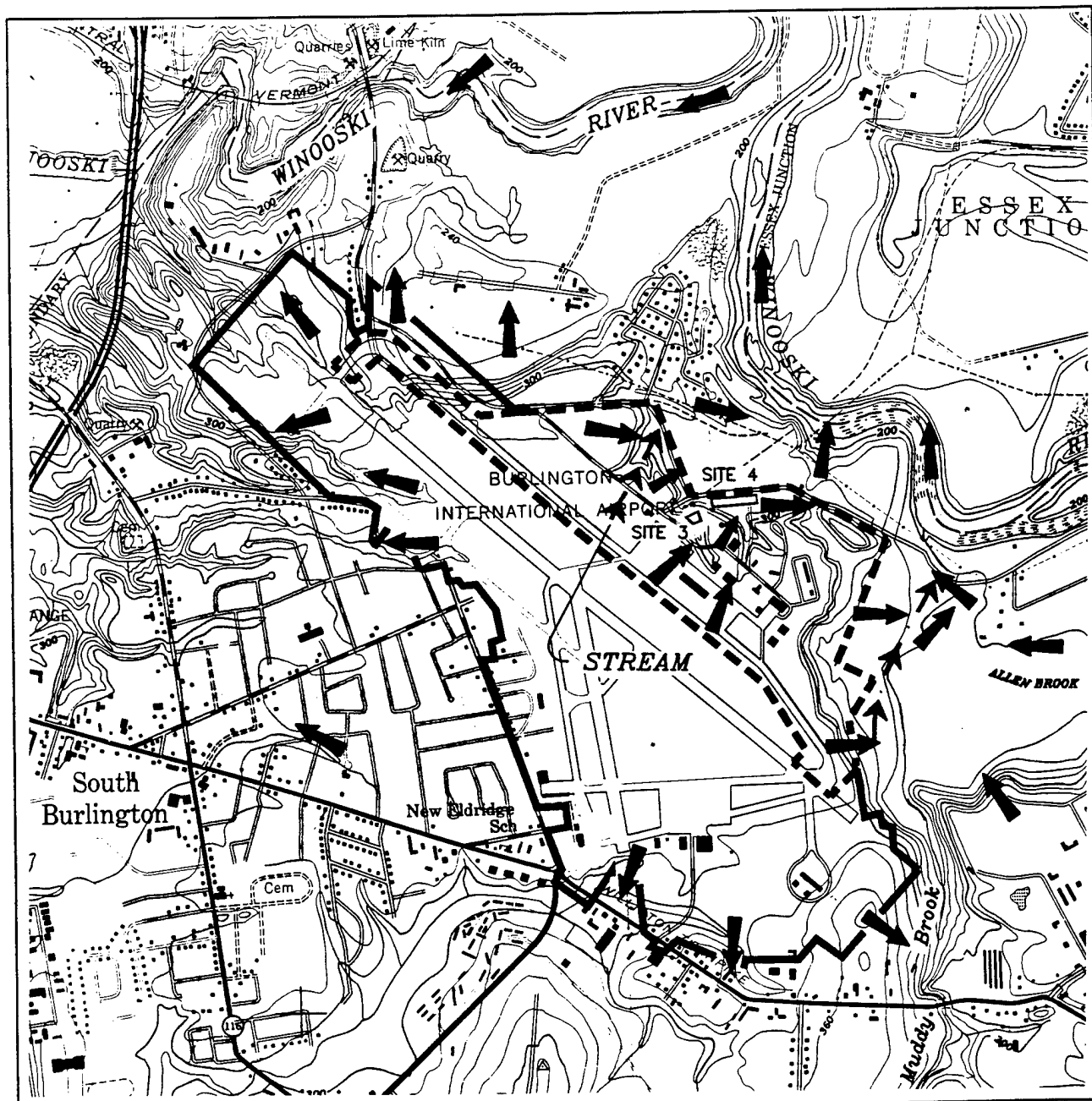
Precipitation is generally plentiful and well distributed throughout the year. Due to atmospheric shielding by the Adirondack Mountains to the west and the Green Mountains to the east, the Champlain Valley receives somewhat less precipitation than surrounding areas. Mean annual precipitation from 1958 through 1987 was 32.98 inches per year. Average monthly precipitation ranged from 1.68 inches in February to 3.72 inches in August. Maximum 24-hour rainfall accumulations ranged from 1.53 to 3.59 inches. Rainfall is most frequent in the summer months with mean monthly accumulations typically in excess of 3 inches. Net precipitation for the Burlington area is estimated in the vicinity of 9 inches per year (CH₂M Hill 1983). Snowfall accumulations generally occur from October to May. The mean annual snowfall from 1958 through 1987 was 78 inches. Mean monthly snowfall accumulations are normally highest from December through March, with accumulations typically in excess of 12 inches.

Most winds are northerly or southerly, due to the orientation of the Champlain Valley between mountain ranges; however, the prevailing direction is southerly. The mean annual wind speed is typically 8-9 miles per hour.

3.3 Surface Water Hydrology

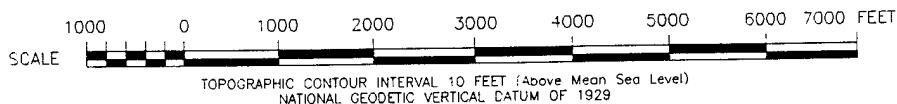
Western Chittenden County is drained by various rivers and streams which eventually empty into Lake Champlain along the western boundary of the county. The northern Burlington area is drained primarily by the westward-northwestward flowing Winooski River and its tributaries. The Winooski River flows northeast of the Vermont ANG Base and through the northeast portion of Burlington. The headwaters of the Winooski River are located east of the Green Mountains, in the rolling plateau area of east-central Vermont.

Surface drainage from Vermont ANG Base and the northwest portion of Burlington International Airport is transmitted to the Winooski River via various tributaries (Figure 3-2). The base is located approximately 0.5 mile south and 0.25 mile or less west-southwest of the Winooski River. Surface drainage on the base is primarily transmitted to the northeast boundary area of the base via various intermittent streams, storm sewer systems, and drainage ditches (Figure 3-2). The east-southeast portion of the base transmits surface



"BURLINGTON QUADRANGLE, VERMONT-CHITTENDEN COUNTY,
7.5 MINUTE SERIES (TOPOGRAPHIC),
UNITED STATES GEOLOGICAL SURVEY, 1948, PHOTOREVISED 1987.

LATITUDE: 44 28' 30"N
LONGITUDE: 73 08' 30"W
UTM COORDINATES: 4926000mN 647000E



- INSTALLATION BOUNDARY - VERMONT AIR NATIONAL GUARD BASE/ BURLINGTON NATIONAL AIRPORT
- SURFACE WATER FLOW DIRECTION
- INTERMITTENT STREAM
- INSTALLATION RESTORATION PROGRAM SITE BOUNDARY (SITES 3 AND 4)

LOCAL SURFACE WATER FLOW MAP
VERMONT AIR NATIONAL
GUARD BASE AREA
SOUTH BURLINGTON, VERMONT

EARTH TECH

FIGURE 3-2

SWFLOW.DWG

drainage eastward to Muddy Brook, which joins Allen Brook less than 1000 ft upstream of its junction with the Winooski River (Figure 3-2). Muddy Brook, Allen Brook, and the Winooski River are considered class B water sources by the State of Vermont (Vermont 1992b). Class B water sources are considered suitable for bathing and recreation, irrigation, and agricultural uses; are good fish habitats; and are acceptable for public water supply, with filtration and disinfection (Vermont 1992a).

Surface drainage in the vicinity of IRP Sites 3 and 4 is transmitted via storm sewer systems and drainage ditches to the base boundary drainage ditch south of Poor Farm Road (Figure 3-3). On-site storm sewer systems consist of a combination of 8-inch to 40-inch diameter CMP and concrete piping, and 6-inch to 12-inch clay piping. Surface water transmitted to the base boundary drainage ditch, beginning in Site 4, flows intermittently west to east and eventually flows off-site northward to the Winooski River. Surface water flow directions and subsurface storm sewer piping in the vicinity of Sites 3 and 4 are presented in Figure 3-3. Storm drainage exiting the eastern portion of Site 4 is transmitted along the base boundary drainage ditch, which features three sheetpile weirs to impede flow (Figure 1-2). One 40-inch diameter asphalt covered CMP, located approximately 800 ft east-southeast of Site 4, directs flow from the ditch off-site, northward to the Winooski River. The outfall of the off-base CMP is located approximately 700 ft northeast of Poor Farm Road.

3.4 Geologic Setting

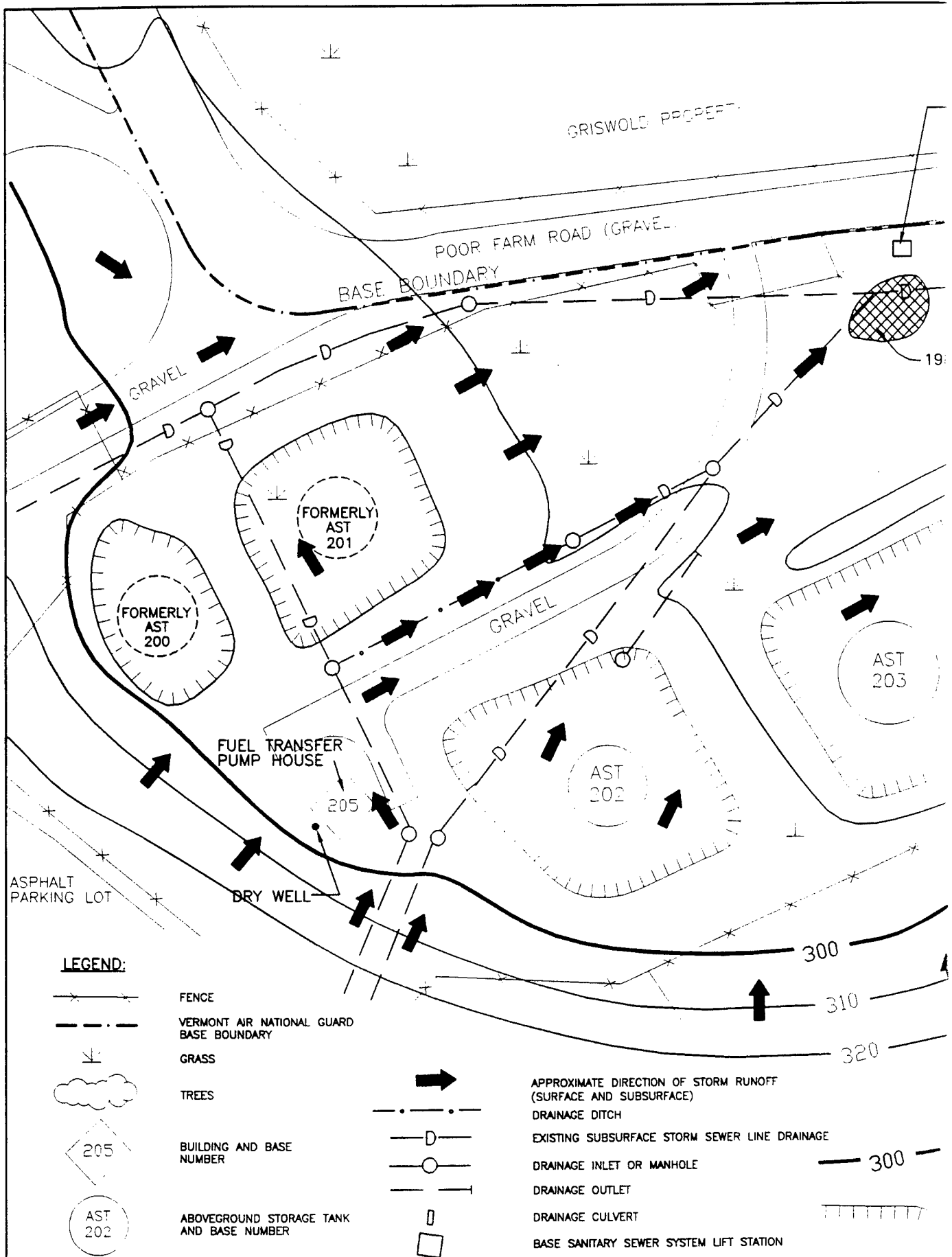
Discussions of the regional and local geologic settings are presented in the following sections.

3.4.1 Regional Geology

The present geology of the Champlain Lowland has resulted principally from Paleozoic-era depositional and tectonic activity, and more recent Quaternary-age glacial, marine, and alluvial depositional and erosional processes. The regional geology of the area is presented in the following discussions of bedrock and surficial sediments.

Bedrock

A regional geologic map, illustrating the distribution of bedrock units and structural features such as major faults and folds, and a general stratigraphic column are presented in Figure 3-4. Bedrock of the Champlain Lowland primarily consists of highly fractured, horizontal to low angle dipping beds of Cambrian to Ordovician-age limestone and dolostone (carbonates), and sandstones and shales (clastics) (USDA 1989). The originally sedimentary bedrock units were subjected to Paleozoic-era tectonism and low grade metamorphism, resulting in areas of altered carbonate and clastic lithologies, typically limestone to dolomitic marble, quartzite, and slate (Stewart 1973). The level of metamorphism was generally low, with foliation limited to some slate beds (Stewart 1973). Additionally, Mesozoic-age igneous rock deposits, principally Bostonite or Camptonite dikes, are present locally in the Champlain Lowland (Stewart 1973). In contrast, bedrock units of the Green Mountains, east of the Champlain Lowland, were subjected to more intense metamorphism, resulting in typically foliated higher grade metamorphic lithologies.



RISWOLD PROPERTY

SANITARY SEWER PUMP BOX

D (GRAVEL)

DITCH

1988 EXCAVATION AREA

AST 203

AST 202

ASPHALT PARKING LOT

NOTE DIRECTION OF STORM RUNOFF AND SUBSURFACE)

DITCH

SUBSURFACE STORM SEWER LINE DRAINAGE

INLET OR MANHOLE

OUTLET

CULVERT

STORM SEWER SYSTEM LIFT STATION

300

TOPOGRAPHIC CONTOUR IN FEET ABOVE MEAN SEA LEVEL
(DATA FROM BASE SURVEY)
(CONTOUR INTERVAL - 10 FEET)

EARTHEN BERM
(TICK MARKS ON DEPRESSION SIDE)



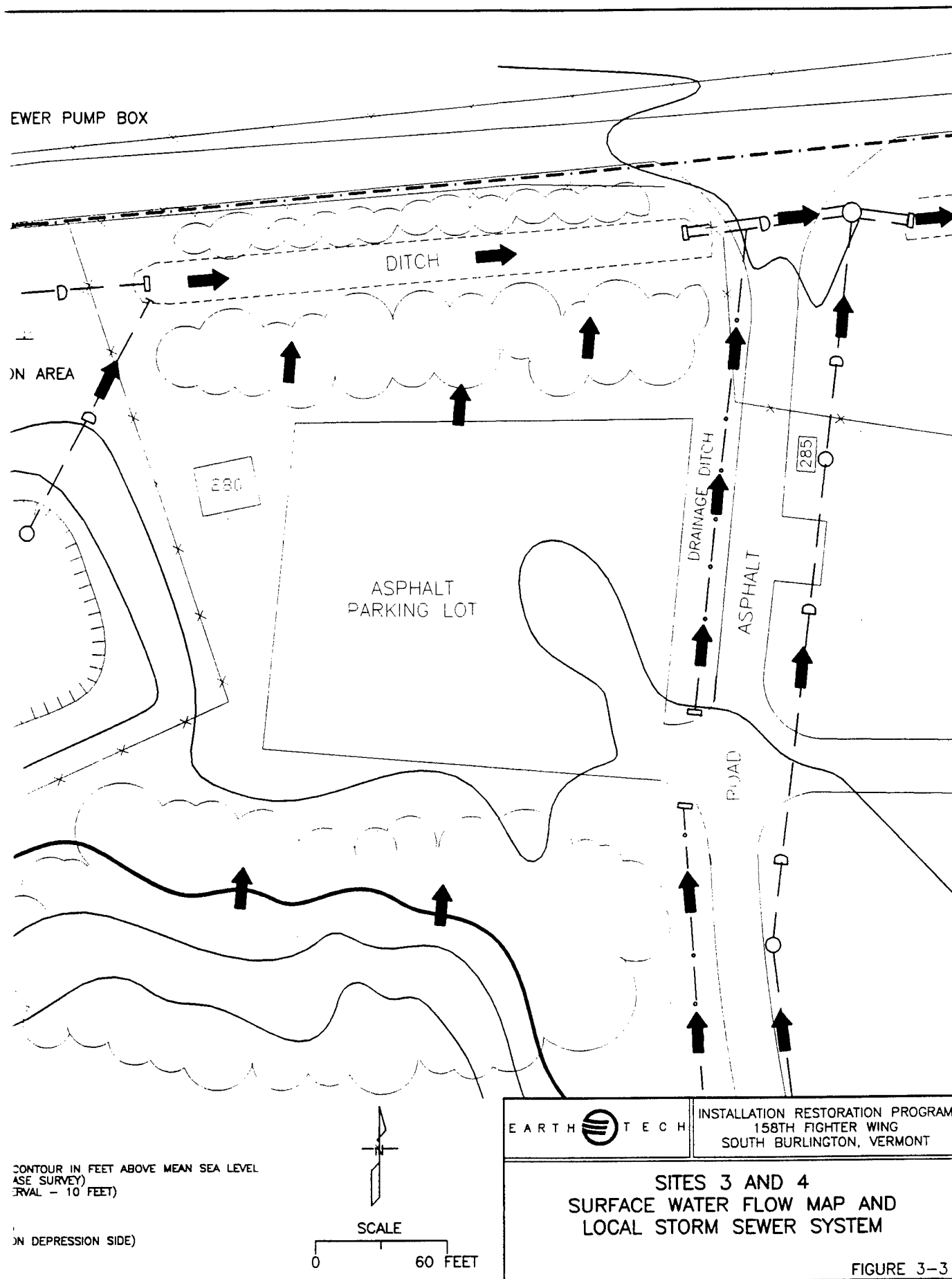
SCALE

0 60 FEET

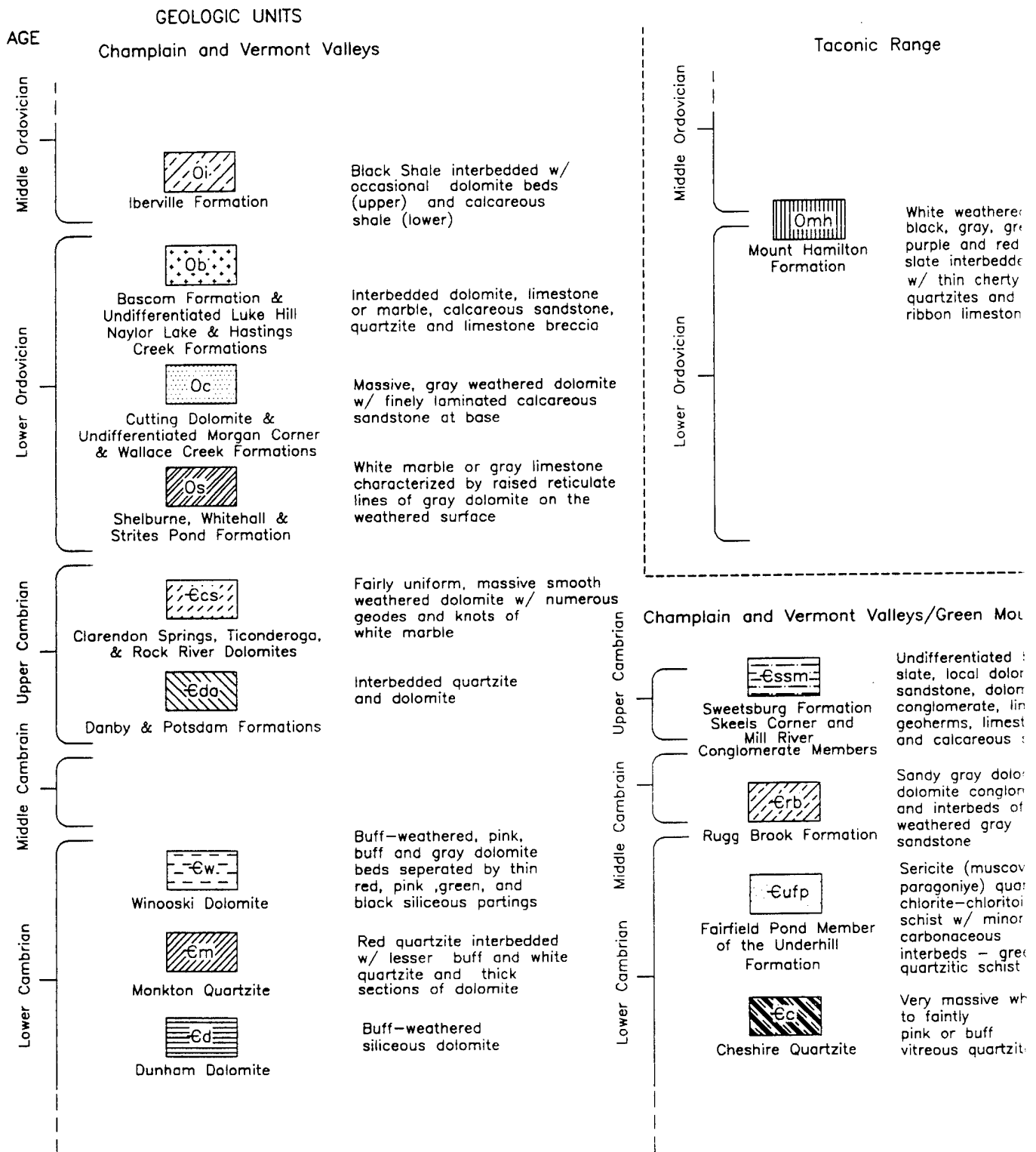
EARTH

SURF/
LOC.

2



LEGEND



SOURCE: "Centennial Geologic Map of Vermont," Charles G. Doll et al, Vermont Geological Survey, scale 1:250,000, 1961.

Taconic Range

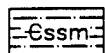
Middle Ordovician

Lower Ordovician



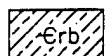
White weathered black, gray, green, purple and red slate interbedded w/ thin cherty quartzites and ribbon limestones

Champlain and Vermont Valleys/Green Mountains



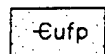
Sweetsburg Formation
Skeels Corner and
Mill River
Conglomerate Members

Undifferentiated black slate, local dolomite sandstone, dolomite conglomerate, limestone geohems, limestone and calcareous shale



Rugg Brook Formation

Sandy gray dolomite, dolomite conglomerate and interbeds of weathered gray sandstone



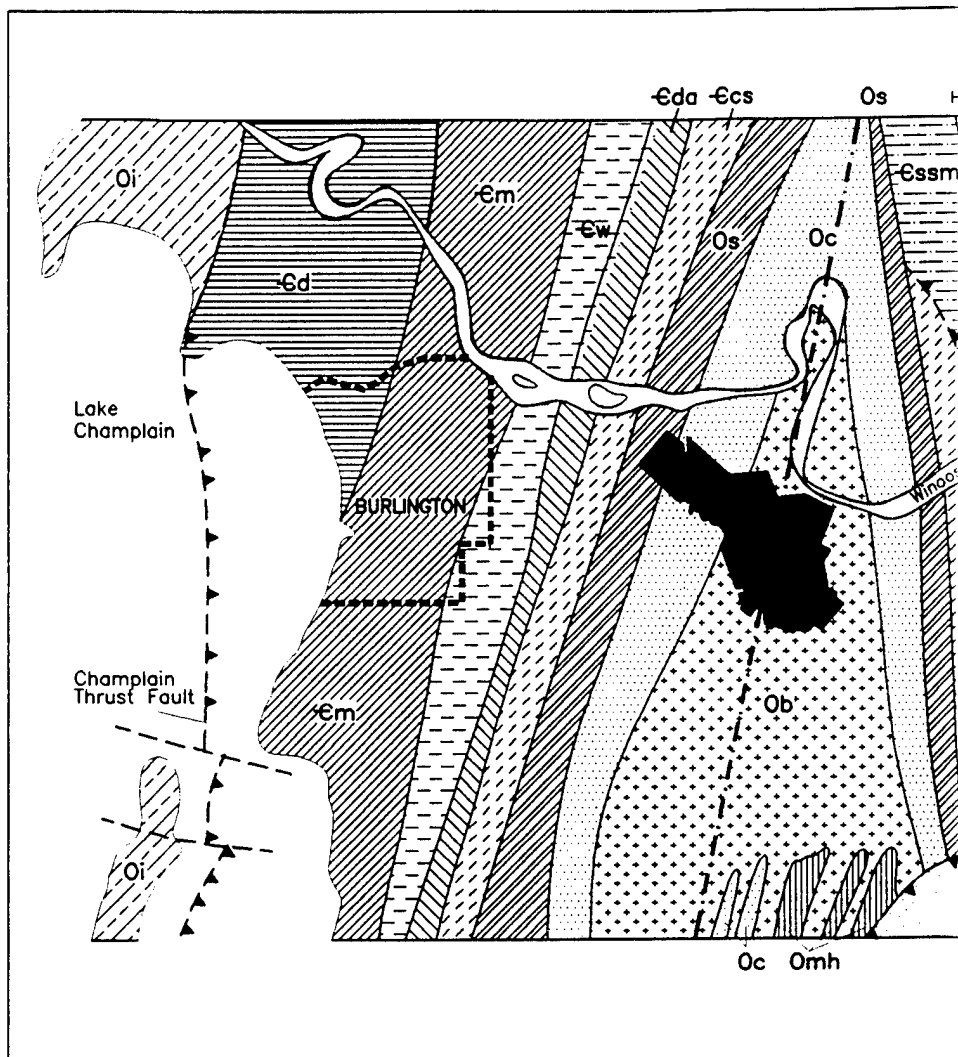
Fairfield Pond Member
of the Underhill
Formation

Sericite (muscovite paragoniye) quartz-chlorite-chloritoid schist w/ minor carbonaceous interbeds - greenish quartzitic schist



Cheshire Quartzite

Very massive white to faintly pink or buff vitreous quartzite



SCALE IN FEET



GEOLOGIC FEATURES

▲▲▲▲ THRUST FAULT (SAWTEETH ON THE UPTHROWN BLOCK)

— GEOLOGIC FORMATION BOUNDARY

- - - - PRIMARY AXIS OF THE HINESBURG SYNCLINORIUM

OTHER FEATURES



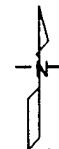
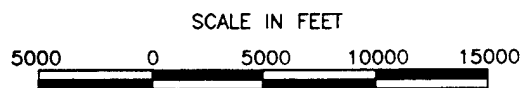
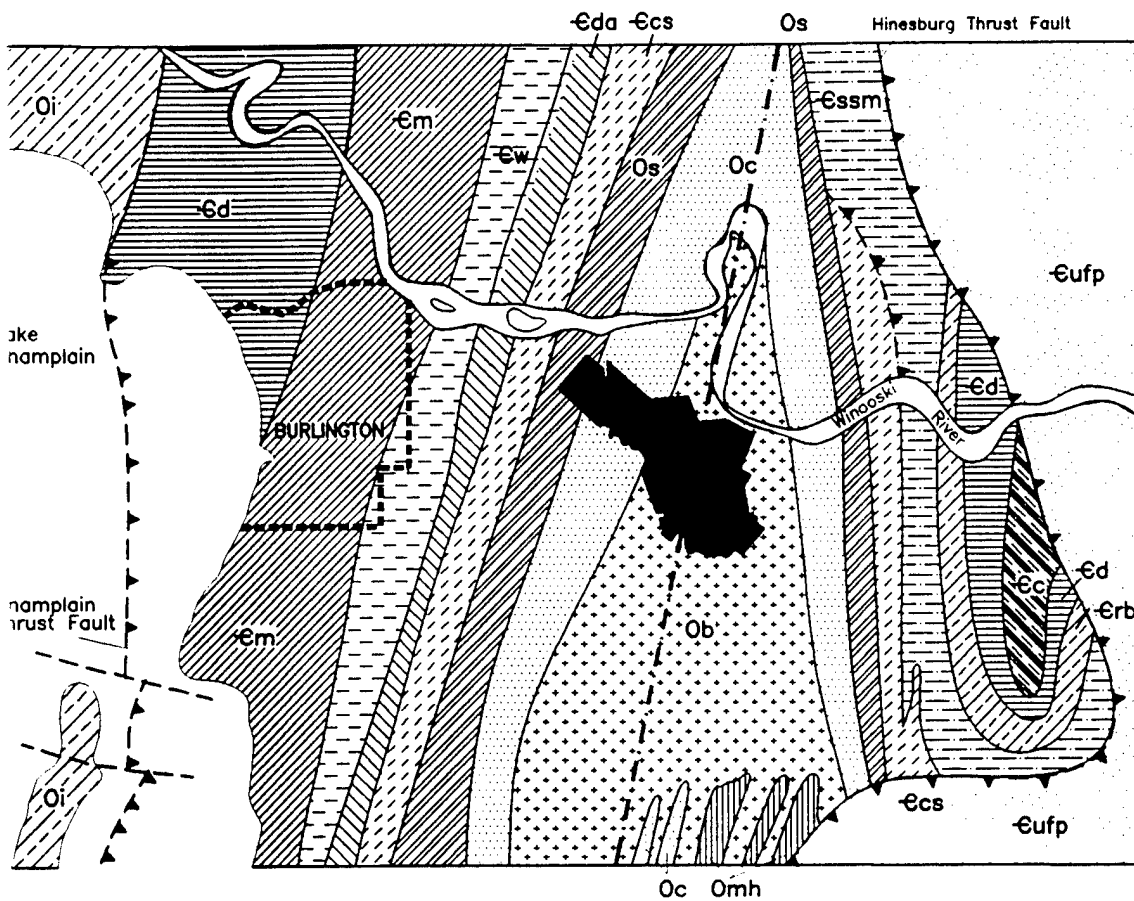
VERMONT AIR NATIONAL GUARD BASE/
BURLINGTON INTERNATIONAL AIRPORT



BURLINGTON CITY BOUNDARY

EARTH T E

REGIO
VERMONT AIR



GEOLOGIC FEATURES

- ▼▼▼▼ THRUST FAULT (SAWTEETH ON THE UPTHROWN BLOCK)
- GEOLOGIC FORMATION BOUNDARY
- - - - PRIMARY AXIS OF THE HINESBURG SYNCLINORIUM

OTHER FEATURES

- VERMONT AIR NATIONAL GUARD BASE/
BURLINGTON INTERNATIONAL AIRPORT
- BURLINGTON CITY BOUNDARY

EARTH TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
SOUTH BURLINGTON, VERMONT

REGIONAL GEOLOGIC MAP
VERMONT AIR NATIONAL GUARD BASE AREA

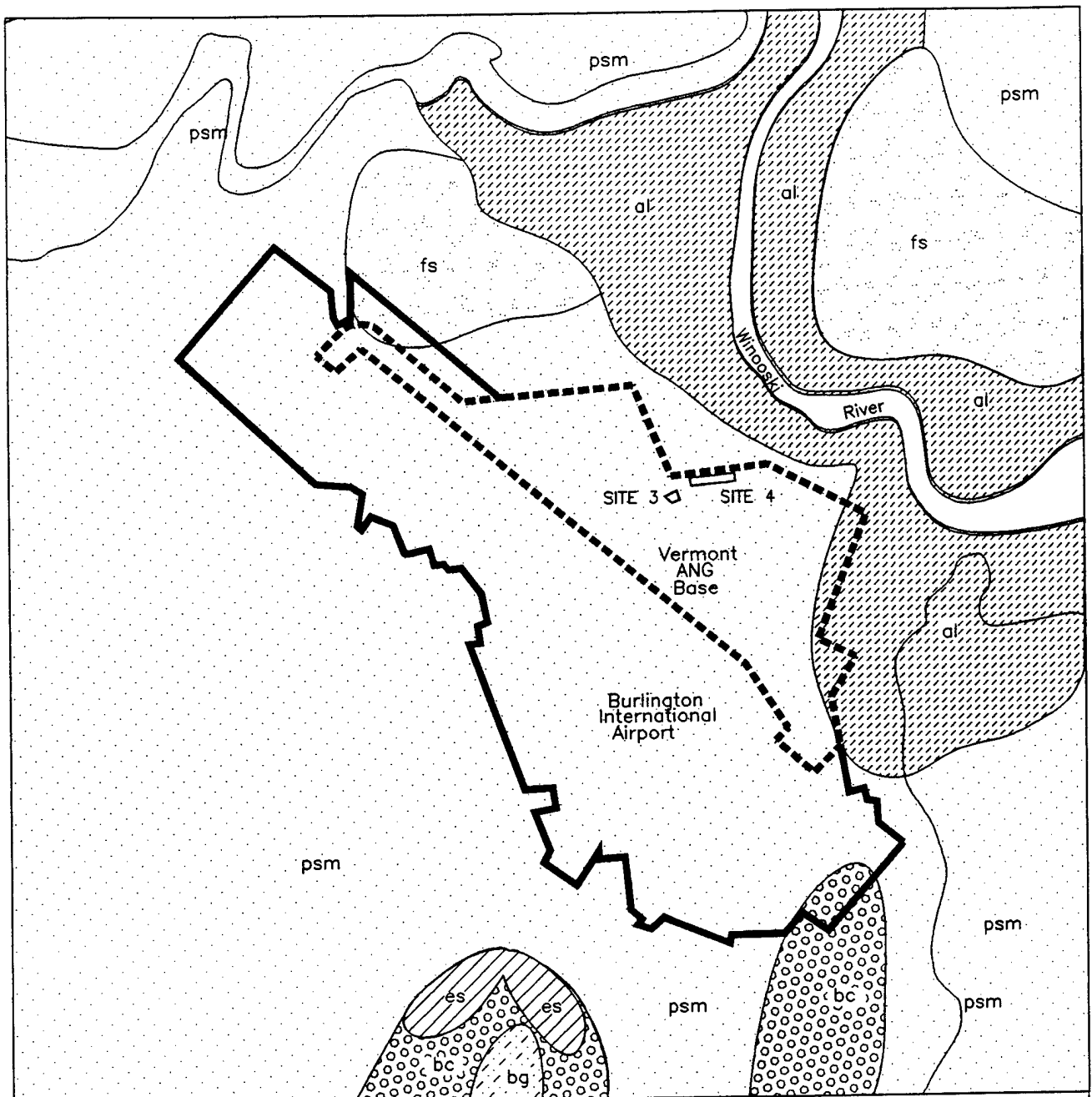
FIGURE 3-4

Structurally, the Champlain Lowland is dominated by two north to south trending structural basins (synclinalia); the Middlebury synclinalium to the south and the Hinesburg synclinalium to the north (Doll, et al 1961). The Hinesburg synclinalium is located along western Chittenden County, approximately five miles north of the Middlebury synclinalium. The Burlington area is located on the west flank of the Hinesburg synclinalium (Figure 3-4). Each synclinalium consists of composite synclinal structures of lower Paleozoic-age bedrock units, resulting from Paleozoic-era tectonic activity. Paleozoic-age thrust faults, roughly north to south trending, are also characteristic of the Champlain Lowland. Major thrust fault blocks were advanced from east to west, resulting in areas of older Cambrian-age bedrock overlying younger Ordovician-age bedrock. Uplift and tilting of overthrust bedrock in the Champlain Lowland is evidenced by hills of eastward dipping strata, with steepest slopes facing west (Stewart 1973). Two major thrust faults are located west and east of the Hinesburg synclinalium; the Champlain thrust fault to the west, and the Hinesburg-Oak Hill thrust fault to the east (Doll, et al 1961) (Figure 3-4). The Champlain thrust fault near the eastern shore of Lake Champlain extends along the northern portion of the Champlain Lowland, from the Canadian border to southernmost Chittenden County. The Hinesburg-Oak Hill thrust fault extends from south of Chittenden County, near the town of Hinesburg, to the Canadian border. The Hinesburg portion of the fault is south of the Winooski River, and the Oak Hill portion of the fault is north of the Winooski River (Stewart 1973). The extent of the Hinesburg-Oak Hill fault forms the structural boundary between the Champlain Lowlands and the Green Mountains (Stewart 1973). In addition to thrust faults, north-south and east-west trending high-angle faults and jointing and fracturing of bedrock without displacement are common in the Champlain Lowland (Stewart 1973).

Thicknesses of Paleozoic-age bedrock units vary locally depending upon thinning or thickening effects of regional or local erosion, faulting, and folding. The Paleozoic-age bedrock of the Champlain Lowland was subjected to post-Paleozoic era erosion which further altered the bedrock surface, as evidenced locally by irregular bedrock surfaces and paleovalleys or depressions. Solution weathering features, such as solution cavities, are also present locally in carbonate units (Stewart 1973). Depth to bedrock varies greatly throughout the Champlain Valley, typically ranging from 0 to 475 ft bgs (Weston 1986).

Surficial Sediments

A regional surficial geologic map of Quaternary-age sediments are presented in Figure 3-5. The Champlain Lowland has been subjected to various late Pleistocene-age glacial advances and retreats. The two most recent, and significant, glaciations occurred during the Wisconsinian glacial episode, which ended approximately 8,000 to 10,000 years ago. These glaciations are, from older to younger, the Shelburne and Burlington glacial stades (Stewart and MacClintock 1969). The Shelburne glacier advanced from the northeast and covered most of Vermont. The Burlington glacier advanced from the north-northwest and covered the Champlain Lowland, extending across the Green Mountains into eastern Vermont (Stewart and MacClintock 1969). These two glacial advances and retreats resulted in regional to local erosion and deposition. Deposits of glacial sediments generally ranged from unsorted tills to sorted outwash deposits, typically kame terrace deposits consisting of silt, sand, and gravel. Ice-marginal and post-glacial lacustrine and marine environments were associated with each glaciation (Stewart and MacClintock 1969). According to Stewart (1973), typically unsorted tills do not cover the present Champlain Lowland below elevations of 700 ft AMSL, the



SOURCE: "SURFICIAL GEOLOGIC MAP OF VERMONT" BY STEWART, D.P. AND MacLINTOCK, P. (COMPILED AND EDITED BY DOLL, C.G.), VERMONT GEOLOGICAL SURVEY, SCALE 1:250,000, 1970.

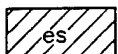
1000 0 1000 2000 FEET

LATITUDE: 44° 28' 30" N
LONGITUDE: 73° 08' 30" W
UTM COORDINATES: 492600mN 647000E

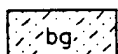
LEGEND

QUATERNARY-AGE SURFICIAL SEDIMENTS

EOLIAN

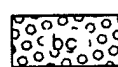


EOLIAN SAND AND DUNES



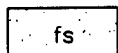
BEACH GRAVEL

GLACIOLACUSTRINE LAKE BOTTOM SEDIMENTS



SILT, SILTY CLAY, AND/OR CLAY CONTAINING ICE RAFTED BOULDERS

POSTGLACIAL FLUVIAL

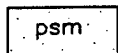


FLUVIAL SAND

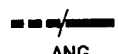


RECENT ALLUVIUM

CHAMPLAIN SEA



PEBBLY MARINE SAND



BASE/AIRPORT BOUNDARY

ANG

AIR NATIONAL GUARD



INSTALLATION RESTORATION PROGRAM SITE BOUNDARY (SITES 3 AND 4)

REGIONAL SURFICIAL GEOLOGY MAP VERMONT AIR NATIONAL GUARD BASE AREA SOUTH BURLINGTON, VERMONT

EARTH  TECH

FIGURE 3-5

approximate location of the ice margin during the Burlington glaciation, which was located in Lake Vermont. Lake Vermont and other marginal glacial lakes were formed by ice and sediment dams (USDA 1989). Reworking of sediments in the lacustrine areas reportedly resulted in sorting of till material mixed with greater amounts of sand, cobbles, and boulders (Stewart 1973). Subsequent retreat of the Burlington glacier was followed by lacustrine sedimentation during the extent of Lake Vermont. The main ice dam subsequently melted effecting the recession of Lake Vermont. Later, a global rise in sea level effected the transgression of the Champlain Sea, and subsequent marine sedimentation (Stewart and MacClintock 1969). The Champlain Sea retreated as the region experienced post-glacial uplift, which resulted in present-day elevations AMSL (USDA 1989). Lacustrine and marine sediments deposited in the Champlain lowlands consist of various clays, silts, sands, and gravels, with local occurrences of glacial erratic cobbles and boulders, which dropped from floating glacial ice (Stewart 1973). Sand and gravel deposits include wave terrace, beach, and deltaic deposits (Stewart 1973). Varved lacustrine clays and silts occur also. The areal extent of lacustrine and marine deposits vary locally. The Burlington area is chiefly underlain by marine sands (Connally and Calkin 1972). Recent alluvium, consisting largely of reworked glacial and post-glacial sediments, are present along stream and river valleys (Stewart 1973). Peat deposits are present locally in swampy areas (Stewart 1973).

3.4.2 Local Geology

Previous geologic studies on Vermont ANG Base have focused on the northwest (IRP Site 1) portion of the base. No previous geologic studies have been conducted in the vicinity of IRP Sites 3 and 4. The local geology of the northwest portion of Vermont ANG Base is presented in the following discussions of bedrock and surficial sediments.

Bedrock

Vermont ANG Base is located on the eastern flank of the Hinesburg synclinorium, approximately three miles east of the Hinesburg-Oak Hill thrust fault (Figure 3-4). The base area is apparently underlain by carbonates of the lower Ordovician-age Beekmantown Group (Doll, et al, 1961). The Beekmantown Group in the vicinity of the base reportedly consists of limestones, dolstones, and marbles of (from younger to older) the Bascom Formation, and the Cutting dolomite (Figure 3-4). Weston (1986) described bedrock in the northwest portion of the base (IRP Site 1) as fractured limestone marble bedrock of the Bascom Formation. The bedrock surface is reportedly irregular, evidenced by variable depths to bedrock ranging from 0 to greater than 88 ft (Weston 1986). A bedrock depression was identified near the main gate on NCO Drive. The bedrock surface reportedly slopes up northward-northeastward from this depression.

Surficial Sediments

A generalized stratigraphic sequence of the northwest portion of the base is as follows: approximately 9 to 50 ft of unconsolidated marine sand and silts underlain by less than 1 ft to approximately 16 ft of lacustrine clay with minor silt and gravel, which overlies either bedrock or bouldery till (Weston 1986). The occurrence of the bouldery till (in excess of 22 ft thick) was limited to a thick sequence of overburden overlying the bedrock depression near

the main gate on NCO Drive. A generalized stratigraphic column, prepared by Weston (1986) for IRP Site 1 in the northwest portion of the base, is presented in Figure 3-6.

The northwest portion of the base is primarily located on the broad alluvial terrace overlooking the Winooski River Valley. IRP Sites 3 and 4 are located on the down side of this escarpment. There, surficial sediments have likely been reworked, at least to some extent, by more recent alluvial processes of the Winooski River and its tributaries.

3.4.3 Local Soils

Soils present on and adjacent to the Vermont ANG Base primarily consist of Adams and Windsor loamy sands (USDA 1989). These soils are typified by very well drained, loamy, sandy soils, which develop on level to steep terrain in areas of water deposited sediments, including deltas, old lake beaches, and terraces (USDA 1989). Soils containing increased volumes of gravel and cobblestones (15 percent or greater) may occur locally, typically at depths between 10 and 40 inches bgs. Depth to bedrock typically averages 5 ft bgs or greater, and vertical permeabilities are typically high, ranging from 6.3 to 20 inches per hour (USDA 1989).

Limerick-Hadley-Winooski association soils are present north-northeast of the base, adjacent to the Winooski River (USDA 1989). Limerick-Hadley-Winooski association soils, typified by poorly drained to well drained loamy soils, reportedly develop on level to nearly level terrain on alluvial bottomlands subject to flooding (USDA 1989).

A map of soil types in the base area is presented in Figure 3-7. Soils in the vicinity of IRP Sites 3 and 4 reportedly consist of Adams and Windsor loamy sands and fill land, consisting of reworked or built-up soils and sediments.

3.5 Hydrogeologic Setting

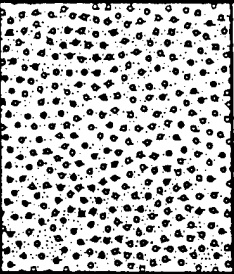
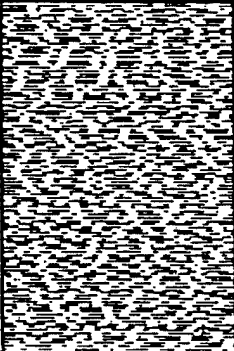

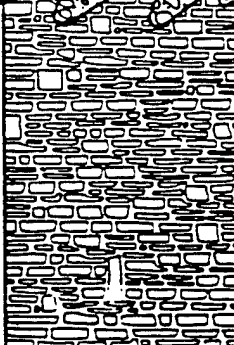
Discussions regarding the regional and local hydrogeologic settings are presented in the following sections.

3.5.1 Regional Hydrogeology

Stewart (1973) noted four significant modes of groundwater occurrence in the Champlain Lowland: in zones of intensely faulted bedrock, in zones of fractured bedrock, in solution cavities and enlarged fractures in carbonate bedrock, and in unconsolidated sediments, particularly stream valley sediments. The regional hydrogeology of the Champlain Lowland is presented further in the following discussions of bedrock and surficial sediment aquifers.

Bedrock

Metamorphosed bedrock units in the Champlain Lowland typically contain no primary porosity, due to recrystallization and filling of intergranular voids (Stewart 1973). Therefore, the occurrence of groundwater is generally dependent upon the development of secondary porosity and permeability, principally due to the presence of fractures (Stewart 1973).

ERA	Period	EPOCH	Unit	Columnar Section	Thickness In Feet	Typical Lithologic Characteristics
Cenozoic	Quaternary	Recent	Fill/Landfill		0-7'	
		Pleistocene	Deltaic Deposits		9-50'	Fine to Coarse Brown to Gray Sand to Sandy Silt
			Lacustrine/ Marine Deposits		4"-16'	Gray to Blue Gray Clay, and Silty Clay, Trace Gravel
			Gravelly Glacial Till and Boulders		0-22+'	Gray Nonstratified Boulders, Gravel, Sand Silt, and Clay Admixtures Angular to Subangular Cobbles
Paleozoic	Ordovician		Unconformity Beekmantown Group Bascom Formation			White Crystalline Limestone

(FROM WESTON 1986)

GENERALIZED STRATIGRAPHIC COLUMN
FOR SITE 1
VERMONT AIR NATIONAL
GUARD BASE AREA
SOUTH BURLINGTON, VERMONT

EARTH  TECH

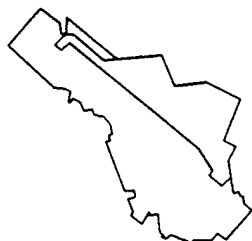
GUIDE TO SOIL MAPPING UNITS

MAP
SYMBOL

MAPPING UNIT

AdA	Adams and Windsor loamy sands, 0 to 5 percent slopes
AdB	Adams and Windsor loamy sands, 5 to 12 percent slopes
AdD	Adams and Windsor loamy sands, 12 to 30 percent slopes
AdE	Adams and Windsor loamy sands, 30 to 60 percent slopes
AgA	Agawam fine sandy loam, 0 to 5 percent slopes
AgD	Agawam fine sandy loam, 12 to 30 percent slopes
AgE	Agawam fine sandy loam, 30 to 60 percent slopes
Be	Beaches
Bo	Blown-out land
Br	Barrow Pit
DdA	Duane and Deerfield soils, 0 to 5 percent slopes
EwA	Enosburg and Whately soils, 0 to 3 percent slopes
EwB	Enosburg and Whately soils, 3 to 8 percent slopes
Fu	Fill land
Hf	Hadley very fine sandy loam
Hh	Hadley very fine sandy loam, frequently flooded
HIB	Hartland very fine sandy loam, 2 to 6 percent slopes
HIC	Hartland very fine sandy loam, 6 to 12 percent slopes
HIE	Hartland very fine sandy loam, 25 to 60 percent slopes
HnB	Hinesburg fine sandy loam, 3 to 8 percent slopes
Le	Limerick silt loam
Lf	Limerick silt loam, very wet
Mp	Muck and peat
MyB	Munson and Raynham silt loam, 2 to 6 percent slopes
ScA	Scantic silt loam, 0 to 2 percent slopes
ScB	Scantic silt loam, 2 to 6 percent slopes
Sd	Scarboro Loam
VeE	Vergennes clay, 25 to 60 percent slopes
Wo	Winooski very fine sandy loam

SOURCE: "SOIL SURVEY REPORT OF CHITTENDEN COUNTY, VERMONT," UNITED STATES DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE IN COOPERATION WITH THE VERMONT AGRICULTURAL EXPERIMENT STATION AND VERMONT DEPARTMENT OF FORESTS AND PARKS, REVISED 1989.



VERMONT AIR NATIONAL GUARD BASE/
BURLINGTON INTERNATIONAL AIRPORT BOUNDARY



INSTALLATION RESTORATION PROGRAM
SITE BOUNDARY (SITES 3 AND 4)

G UNITS

Jamy sands, 0 to 5 percent slopes
 Jamy sands, 5 to 12 percent slopes
 Jamy sands, 12 to 30 percent slopes
 Jamy sands, 30 to 60 percent slopes
 am, 0 to 5 percent slopes
 am, 12 to 30 percent slopes
 am, 30 to 60 percent slopes

soils, 0 to 5 percent slopes
 soils, 0 to 3 percent slopes
 soils, 3 to 8 percent slopes

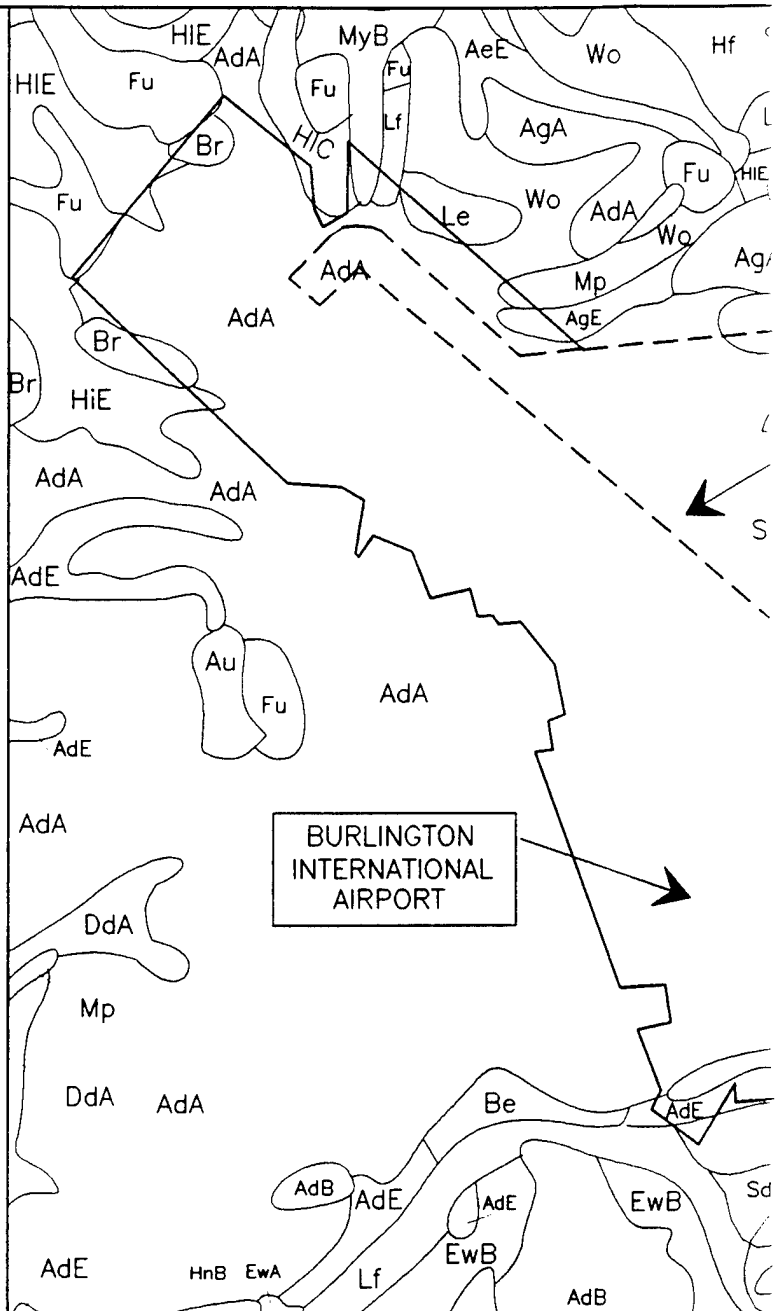
y loam
 y loam, frequently flooded
 dy loam, 2 to 6 percent slopes
 dy loam, 6 to 12 percent slopes
 dy loam, 25 to 60 percent slopes
 loam, 3 to 8 percent slopes

y wet
 silt loam, 2 to 6 percent slopes
 o 2 percent slopes
 o 6 percent slopes
 60 percent slopes
 dy loam

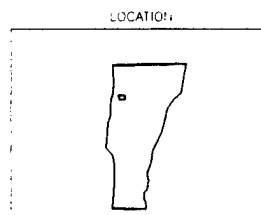
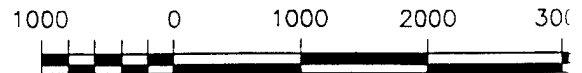
Y, VERMONT, UNITED STATES DEPARTMENT OF
 ION WITH THE VERMONT AGRICULTURAL
 RESTS AND PARKS, REVISED 1989.

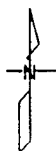
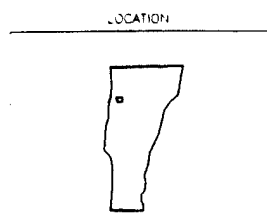
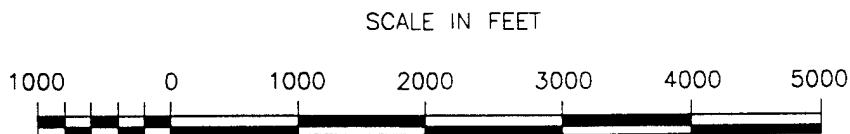
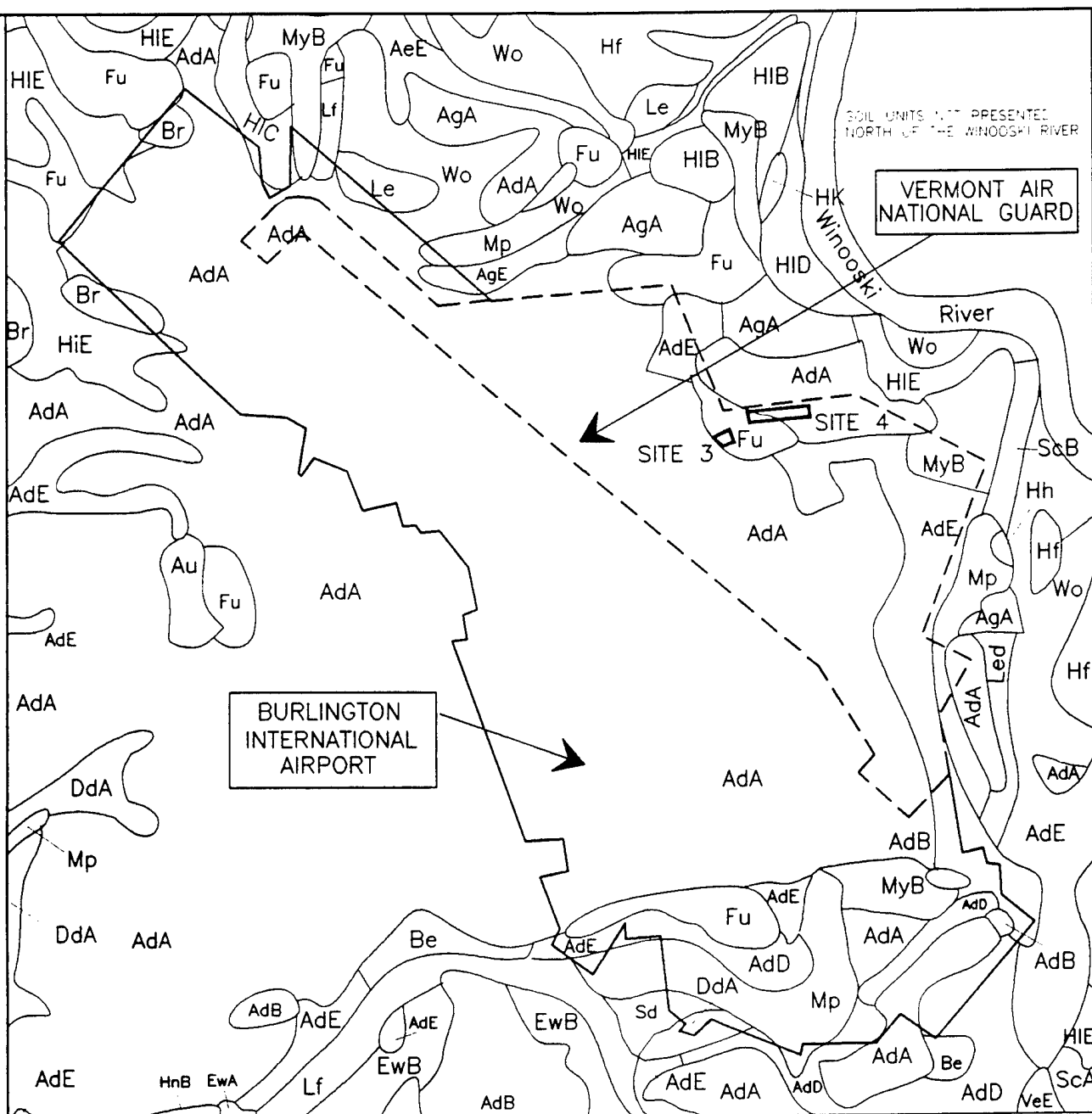
NATIONAL GUARD BASE/
 INTERNATIONAL AIRPORT BOUNDARY

RESTORATION PROGRAM
 Y (SITES 3 AND 4)



SCALE IN FEET





AREA SOILS MAP
VERMONT AIR NATIONAL
GUARD BASE AREA
SOUTH BURLINGTON, VERMONT
EARTH  TECH

FIGURE 3-7

Generally, bedrock units in the Champlain Lowland are highly fractured, and fractures in carbonate bedrock have typically been enlarged by solution weathering (Stewart 1973). Significant, water producing, fracture systems are reportedly located in the uppermost 400 ft of bedrock. Bedrock water wells producing from fractures, generally have low yields, ranging between 2 and 15 gallons per minute (gpm), with some wells producing as much as 50 or 60 gpm (Stewart 1973).

Surficial Sediments

The most prolific and accessible aquifers occur in unconsolidated stream valley sediments, and water wells with the highest yields are typically those which produce from sand and gravel deposits (Stewart 1973). The most productive stream valley sediment aquifers occur in thick deposits (in excess of 100 ft) of sand and gravel in buried paleostream valleys. The courses of streams and rivers have varied through time, and multiple paleostream valleys are typically present along the course of major drainage areas. Therefore, present-day stream and river courses may or may not overly the thicker and more productive stream valley aquifers.

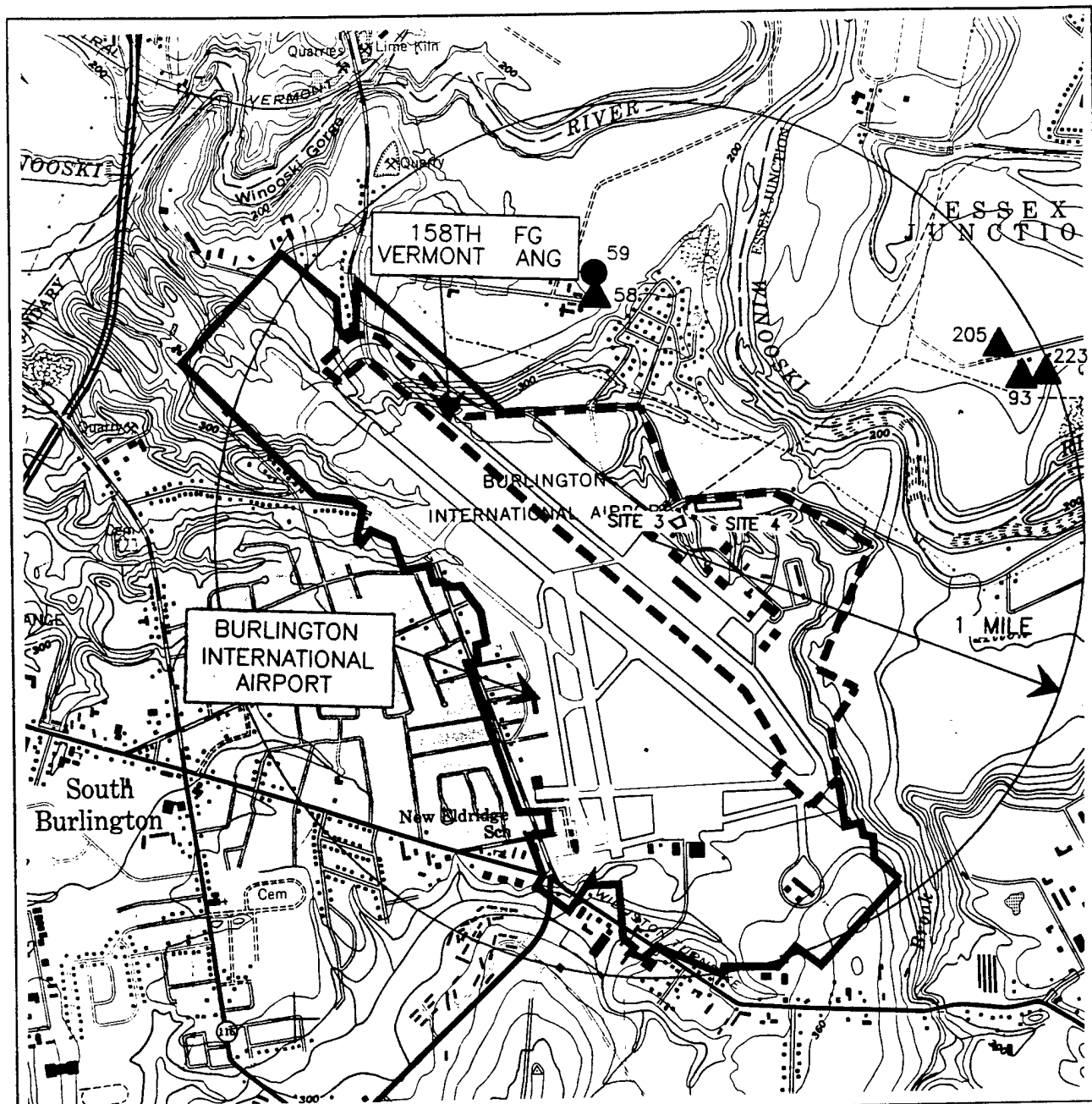
The Winooski River Valley is reportedly the most significant area of surficial sediment aquifers in the Champlain Lowland, except for sections where bedrock forms the stream channel or valley sediments consist of low yielding silts and clays (Stewart 1973). Recorded depths to bedrock along the Winooski River in the Champlain Lowland generally range from 50 to 125 ft bgs (Stewart 1973). Between the falls at Essex Junction and the gorge at Winooski, the river valley widens and is generally filled with significant sand and gravel deposits (Stewart 1973). The base is located south-southwest of this section of the Winooski River Valley. Water wells producing from alluvial sediments along the Winooski River Valley, east of the Williston area, which is southeast of the Vermont ANG Base, have produced 5 to 300 gpm, from depths ranging from 33 to 140 ft bgs (Stewart 1973).

3.5.2 Local Hydrogeology

Local groundwater data in the vicinity of Vermont ANG Base is limited. Therefore, the discussion of local hydrogeology is based on information available from State of Vermont water well records and information derived from previous IRP studies at Sites 1 and 2.

Water well records available from the State of Vermont Department of Water Resources indicate at least five private wells are located within a 1-mile radius of the Vermont ANG Base (Figure 3-8). The State of Vermont has required water well records from well drillers only since 1966. All five wells produce water from uncased sections of limestone/marble bedrock, from depths ranging from 128 to 468 ft bgs. Water yields range from 6 to 40 gpm. The wells were or are currently used for domestic or agricultural purposes; completion dates range from 1975 to 1983. Bedrock groundwater in the area of the Vermont ANG Base is classified as Class III by the Department of Water Resources (Telecon 1995b). According to the Class III designation, such groundwater is suitable as a source of water for individual domestic water supply, irrigation, agricultural use, and general industrial and commercial use (Vermont 1987).

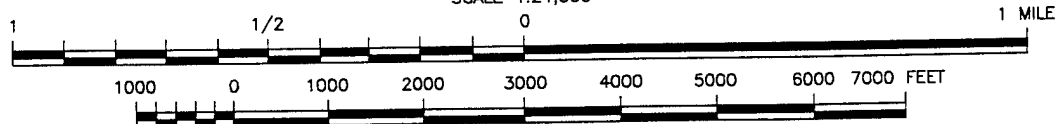
According to Stewart (1973) the base area is located in an area of good to moderate groundwater potential (Figure 3-9). Usable quantities of groundwater are reportedly available from sand and gravel deposits in stream valley sediments, and to a lesser extent from



SOURCE: UNITED STATES GEOLOGICAL SURVEY 7.5 MINUTE QUADRANGLE(S) FOR:
BURLINGTON VERMONT(1948) PHOTO REVISED 1987

LATITUDE: 44° 28' 30" N
LONGITUDE: 73° 08' 30" W
UTM COORDINATES: 4926000mN 647000E

SCALE 1:24,000



TOPOGRAPHIC CONTOUR INTERVAL 10 FEET (Above Mean Sea Level)
NATIONAL GEODETIC VERTICAL DATUM OF 1929

LEGEND:

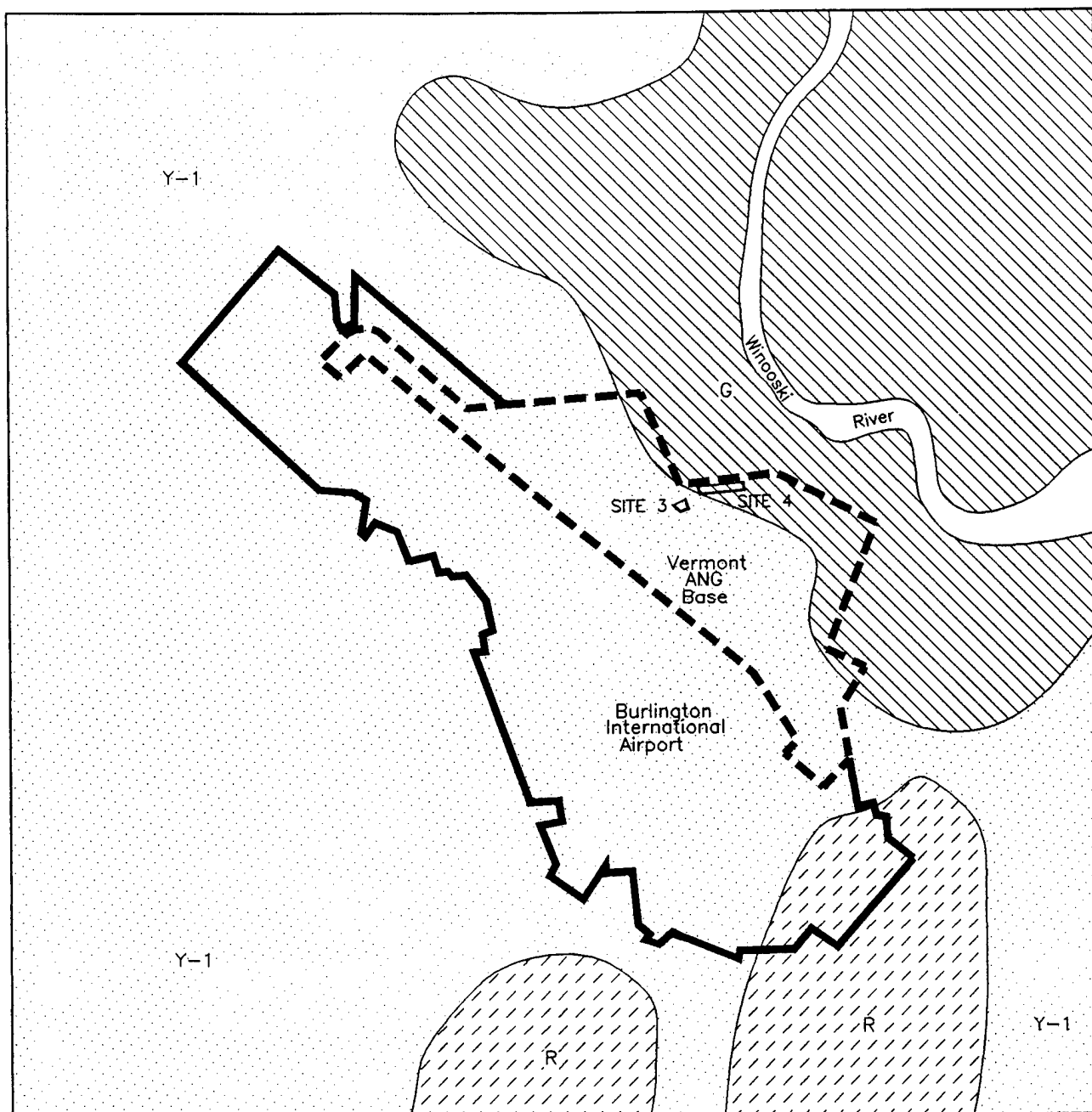
- 205 WELL NUMBER
- ▲ DOMESTIC WELL
- 59 WELL NUMBER
- AGRICULTURAL WELL
- BASE/AIRPORT BOUNDARY
- FG FIGHTER GROUP
- ANG AIR NATIONAL GUARD
- INSTALLATION RESTORATION PROGRAM SITE BOUNDARY (SITES 3 AND 4)

LOCAL WATER SUPPLY MAP
158TH FIGHTER GROUP
VERMONT AIR NATIONAL
GUARD BASE AREA
SOUTH BURLINGTON, VERMONT

EARTH  TECH

FIGURE 3-8

TOPWELL.DWG



SOURCE: GROUND WATER POTENTIAL MAP OF THE BURLINGTON-MIDDLEBURY REGION, FROM STEWART, D.P., 1973, "GEOLOGY FOR ENVIRONMENTAL PLANNING IN THE BURLINGTON-MIDDLEBURY REGION, VERMONT," VERMONT GEOLOGICAL SURVEY AND VERMONT DEPARTMENT OF WATER RESOURCES, NO. 3, 44 p.

LEGEND



AREAS OF GOOD GROUNDWATER POTENTIAL. WATER AVAILABLE IN SAND AND GRAVEL DEPOSITS IN STREAM VALLEYS OR BURIED VALLEYS. WATER YIELD MEDIUM TO HIGH FROM UNCONSOLIDATED SEDIMENTS



AREAS OF MODERATE GROUNDWATER POTENTIAL. WATER AVAILABLE IN SAND AND GRAVEL DEPOSITS IN STREAM VALLEYS OR FROM BEDROCK BELOW THE VALLEY FILL. WATER YIELD LOW TO MEDIUM AT DEPTHS TO 300 FEET



AREAS OF VERY LOW GROUNDWATER POTENTIAL. WATER AVAILABLE IN THESE AREAS FROM LOW YIELD, BEDROCK SOURCES TO DEPTHS OF 300 FEET.

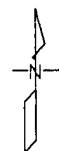
--- BASE/AIRPORT BOUNDARY

ANG

AIR NATIONAL GUARD



INSTALLATION RESTORATION PROGRAM
SITE BOUNDARY (SITES 3 AND 4)



LATITUDE: 44° 28' 30" N
LONGITUDE: 73° 08' 30" W
UTM COORDINATES: 4926000m 647000E

1000 0 1000 2000 FEET

LOCAL GROUNDWATER POTENTIAL MAP
VERMONT AIR NATIONAL
GUARD BASE AREA
SOUTH BURLINGTON, VERMONT

EARTH  TECH

FIGURE 3-9

TOPOPOTN.DWG

underlying fractured bedrock. Water yields are noted as low to high (generally ranging from 5 to 300 gpm), with the areas of greater potential located proximal to the Winooski River. No water wells, producing from the sand and gravel deposits, are documented within a 1-mile radius of the Vermont ANG Base, according to the State of Vermont Department of Water Resources. Groundwater within these deposits is also classified as Class III by the State of Vermont Department of Water Resources (Telecon 1995a).

Based on available information derived from previous IRP activities, three discrete aquifer zones exist locally beneath the northwest portion of Vermont ANG Base (Earth Technology 1991). Two surficial sediment aquifers, separated by a confining to semi-confining clay layer, apparently overlie water bearing zones of fractured limestone marble bedrock of the Ordovician-age Bascom formation. The upper surficial sediment aquifer occurs in marine sands and silts under unconfined (water table) conditions, with the depth to water generally ranging from 10 to 20 ft bgs, depending primarily upon variations in topography. The lower surficial sediment aquifer apparently exists, at least locally, under confined to semi-confined conditions in bouldery till sediments. The underlying fractured bedrock aquifer system may also exist locally under semiconfined to confined conditions; however, based on soil boring logs and other data obtained from the initial RI, the bedrock aquifer appears to be connected locally to the overlying surficial aquifer(s) (Earth Technology 1991).

Slug test data conducted in groundwater monitoring wells screened across the upper surficial sediment aquifer in Site 1 indicated hydraulic conductivities ranging from 1.2×10^{-4} centimeters/second (cm/sec) to 2×10^{-5} cm/sec (Earth Technology 1991). The water table slopes northward and eastward, with horizontal flow gradients ranging from 0.033 to 0.39 and an average horizontal flow velocity of 0.0241 ft/day (assuming a hydraulic conductivity of 6.9×10^{-5} cm/sec and 30% formation porosity) (Earth Technology 1991).

3.6 Water Resources

Groundwater is regarded as a limited resource in the Burlington area (Stewart 1973). As discussed in Section 3.5, groundwater usage within a 1-mile radius of Vermont ANG Base is limited to five domestic/agricultural wells which produce water from sections of limestone/marble bedrock (Figure 3-8). Groundwaters from local bedrock aquifers are classified as Class III by the State of Vermont (Telecon 1995a).

Vermont ANG Base and surrounding areas receive potable water from the City of Burlington, which obtains water for public water supply from Lake Champlain. The intake points are located approximately 0.25 mile offshore at a depth of 50 ft below the water surface (CH₂M Hill 1983).

3.7 Ecology

The biotic environment of the base appears to be typical of the general area. Species sighted on Vermont ANG Base have included deer, snowbird, game fowl, and seagulls. Approximately half of the 223 acres of Vermont ANG Base are undeveloped and consist of fields and wooded areas. Other species which would be expected include a variety of small mammals, birds, and

reptiles (CH₂M Hill, 1983). Species which could inhabit the general area and which have been designated as endangered by the State of Vermont include the Lake Sturgeon, Southern Bald Eagle, American Osprey, American Peregrine Falcon, Indian Bat, Pine Marten, Eastern Cougar, and Canadian Lynx.

4.0 FIELD PROGRAM

The ASI field program activities that EARTH TECH implemented at IRP Sites 3 and 4 of Vermont ANG Base in 1994 are described in this section. The ASI field program was conducted according to the rationale and methodologies presented in the ASI WP (EARTH TECH 1994b) and the SRI SAP (EARTH TECH 1994c). Significant changes to field investigation methodologies are documented on four Field Change Request (FCR) Forms (FCR Forms 1-4), presented in Appendix A.

4.1 FIELD PROGRAM SUMMARY

ASI activities included field screening and confirmation activities. Field screening activities were conducted to provide initial characterization of the extent of target volatile organic compounds (VOCs), and to assist in the placement of confirmation soil borings and monitoring wells. Field screening activities at Sites 3 and 4 consisted of 1) soil organic vapor (SOV) or soil gas surveys, and 2) groundwater screening and temporary piezometer installation. Confirmation activities were conducted to confirm or deny the presence of fuel related contamination in site soils and groundwater, and to characterize site geologic and hydrogeologic conditions. Confirmation activities at Sites 3 and 4 primarily consisted of soil borings and soil sampling, with analyses at an off-site laboratory, installation and development of groundwater monitoring wells, groundwater sampling, with analyses at an off-site laboratory, and water level and free-product measurements in background and site monitoring wells. Confirmation activities conducted at Site 4 also included surface water and sediment sampling, with analyses at an off-site laboratory.

Field screening activities are described in Section 4.2. Confirmation activities are described in Section 4.3. The ASI field program is summarized in Tables 4-1 through 4-3. Table 4-1 presents a summary of ASI field screening and confirmation activities. Table 4-2 presents a summary of field screening sampling and analyses. Table 4-3 presents a summary of confirmation activity sampling and laboratory analyses.

4.2 FIELD SCREENING ACTIVITIES

ASI field screening activities at IRP Sites 3 and 4 were conducted to provide initial characterization of the extent of target VOCs and to assist in the placement of confirmation soil borings and monitoring wells. Field screening activities consisted of 1) SOV or soil gas surveys and 2) groundwater screening and temporary piezometer installation.

The following field screening activities were performed at Sites 3 and 4:

- SOV surveys using an on-site gas chromatograph (GC); a 20 location survey at Site 3 and a 33 location survey at Site 4; 21 samples from Site 3 and 40 samples from Site 4.

**Table 4-1 Summary of Field Screening and Confirmation Activities,
Abbreviated Site Investigation - Installation Restoration Program Sites 3 and 4
Vermont Air National Guard Base**

Investigation Area	Field Screening Activities					Confirmation Activities				
	SOV Locations	Soil Gas Samples ¹	Groundwater Screening Locations/ Samples ¹	Temporary Piezometers	Soil Borings ²	Monitoring Wells ²	Total Borings ²	Soil Boring Samples ¹	Groundwater Samples ^{1,4}	Surface Water ³ / Sediment Samples ¹
Background	0	0	0	0	2	2	2	6	2	0/0
Site 3	20	21	8	0	5	3	8	11	2	0/0
Site 4	33	40	10	3	6	3	8	13	2	1/3
Total	53	61	18	3	13	8	18	30	6	1/3

¹ Excluding Quality Assurance/Quality Control samples.

² Some soil borings and monitoring wells were combined in one location; one background combined location per site, and one combined location in Site 4.

³ Surface water was present in only one of three proposed sampling locations.

⁴ Two monitoring wells were not sampled due to the presence of free-product.

Table 4-2 Summary of Field Screening Sampling and Analysis
Abbreviated Site Investigation - Installation Restoration Program Sites 3 and 4
Vermont Air National Guard Base

Sample Source	Sample Medium	Number of Samples Collected/Analyzed ¹
Site 3	Soil Gas	21
	Groundwater	8
Site 4	Soil Gas	40
	Groundwater	10
Total	Soil Gas	61
	Groundwater	18
Duplicates	Soil Gas	8
	Groundwater	2

¹ Target Volatile Organic Compounds were analyzed according to on-site gas chromatograph headspace methods.

**Table 4-3 Summary of Confirmation Activity Sampling and Laboratory Analysis
Abbreviated Site Investigation - Installation Restoration Program Sites 3 and 4
Vermont Air National Guard Base**

Sample Source	Sample Medium	VOCs - SW-846, 8010/8020 ¹	SVOCs - CLP 3/90 & 10/92 ²	TAL Metals CLP 3/90 ³	TPH Mod. 8015 ⁴
Background ⁵	Soil	6	6	6	6
	Groundwater ⁶	2	2	4	2
Site 3	Soil	11	11	11	11
	Groundwater ⁶	2	2	4	2
Site 4	Soil	13	13	13	13
	Groundwater ⁶	2	2	4	2
	Surface Water	1	1	1	1
	Sediment	3	3	3	3
Total	Soil/Sediment	33	33	33	33
	Groundwater ⁶ /Surface water	7	7	13	7
Field Duplicates ⁷	Soil/Sediment	5	5	5	5
	Water	2	2	4	2
Equipment Rinseates ⁷	Water	7	7	7	7
Field Blanks ⁸	Water	4	4	4	4
Trip Blanks ⁹	Water	15	--	--	--
MS/MSD ¹⁰	Soil/Sediment	4	4	4	4
	Water	2	2	4	2

¹ VOCs - Volatile Organic Compounds were analyzed by U.S. Environmental Protection Agency (EPA) Methods 8010/8020, as stated in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods," SW-846, 3rd Edition, November 1988.

² SVOCs - Semivolatile Organic Compounds were analyzed according to Contract Laboratory Program (CLP) Methods, as stated in "EPA CLP, Statement of Work for Organics, Multi-Media, Multi-Concentration," Revision 3/90 for soils, and Revision 10/92 for waters.

³ TAL - Target Analyte List Metals were analyzed according to CLP Methods, as stated in "EPA CLP, Statement of Work for Inorganics, Multi-Media, Multi-Concentration," Revision 3/90 for soils and waters.

⁴ TPH - Total Petroleum Hydrocarbons were analyzed according to California Modified Method 8015, as stated in "Leaking Underground Fuel Tank (LUFT) Field Manual," State of California Water Resources Board, May 1988.

⁵ One background boring/well was sampled per site.

⁶ Totals for one round of sampling, included filtered and unfiltered samples for TAL metals. Quality Assurance/Quality Control (QA/QC) samples for filtered samples include field duplicates and MS/MSD samples only.

⁷ Collected/analyzed at a frequency of 1/10 environmental samples.

⁸ Collected/analyzed per potable and deionized water sources; potable water blanks per source and sampling event and deionized water blanks per lot number.

⁹ Trip blanks were supplied per cooler used to collect and ship environmental and/or QA/QC samples per day.

¹⁰ MS/MSDs Matrix Spikes/Matrix Spike Duplicates. Collected/analyzed at a frequency of 1/20 environmental samples.

- Groundwater screening using an on-site GC; eight location/samples from Site 3 and ten locations/samples from Site 4.
- Installation of temporary piezometers; three at Site 4.

In August 1994, EnviroSurv, Incorporated of Fairfax, Virginia (EnviroSurv), subcontracted and supervised by EARTH TECH, conducted ASI field screening activities at IRP Sites 3 and 4. All field screening sampling and temporary piezometer installation was done using a 4-wheel drive truck equipped with a hydraulic cylinder/percussion hammer unit. The truck unit drove assemblies of 3-ft length sections of 0.75-inch outer diameter (OD) hardened steel rods, with media-specific sampling probes attached on the ends, into subsurface soils to depths ranging up to 30 ft bgs. Modifications of sampling probes attached to lead steel rods allowed the collection of either soil gas or groundwater screening samples. Soil gas and groundwater screening samples were analyzed in an on-site GC laboratory; a temperature controlled field trailer. Locations overlain by up to 4-inches of asphalt required the use of a rotary drill attachment to bore a 1.5-inch diameter pilot boring. At four locations in the drainage ditch at Site 4, inaccessible to the 4-wheel drive truck, sampling probes were hammered by hand to shallow sampling depths (approximately 5 ft bgs).

Field screening sample collection and analyses were conducted according to HAZWRAP Quality Control (QC) Level B protocols, as stated in "Requirements for Quality Control of Analytical Data" (DOE/HWP-65RI 1990a) and in "Quality Control Requirements for Field Methods" (DOE/HWP-69RI 1990b), and presented in the SRI SAP (EARTH TECH 1994c). HAZWRAP Level B corresponds to U.S. Environmental Protection Agency (EPA) Data Quality Objective (DQO) Level II, as stated in "Data Quality Objectives for Remedial Response Activities Development Process," Office of Solid Waste and Emergency Response (OSWER) Directive 93550-7B, March 1987 (EPA 1987).

Site health and safety (H&S) supervision was conducted by EARTH TECH as specified in the SRI WP (EARTH TECH 1994a). All field screening activities were conducted in personal protective equipment (PPE) Level D. Ambient air in the vicinity of borings and work area breathing zones was monitored for the presence of organic vapors, using a photoionization detector (PID); ThermoEnvironmental® organic vapor meter (OVM), Model 580B.

Daily field screening activities were documented by EARTH TECH in a field logbook, and summarized in the Site Logbook. Field equipment calibration (OVM) was documented in the Field Equipment Calibration Logbook. A report of EnviroSurv field screening activities and analytical results is presented in Appendix B.

Specific field screening activity procedures, including soil gas sampling, groundwater sampling, Quality Assurance/Quality Control (QA/QC) sampling, analytical methods, boring abandonment, decontamination, and waste handling are discussed in the following sections.

4.2.1 Soil Gas Sampling

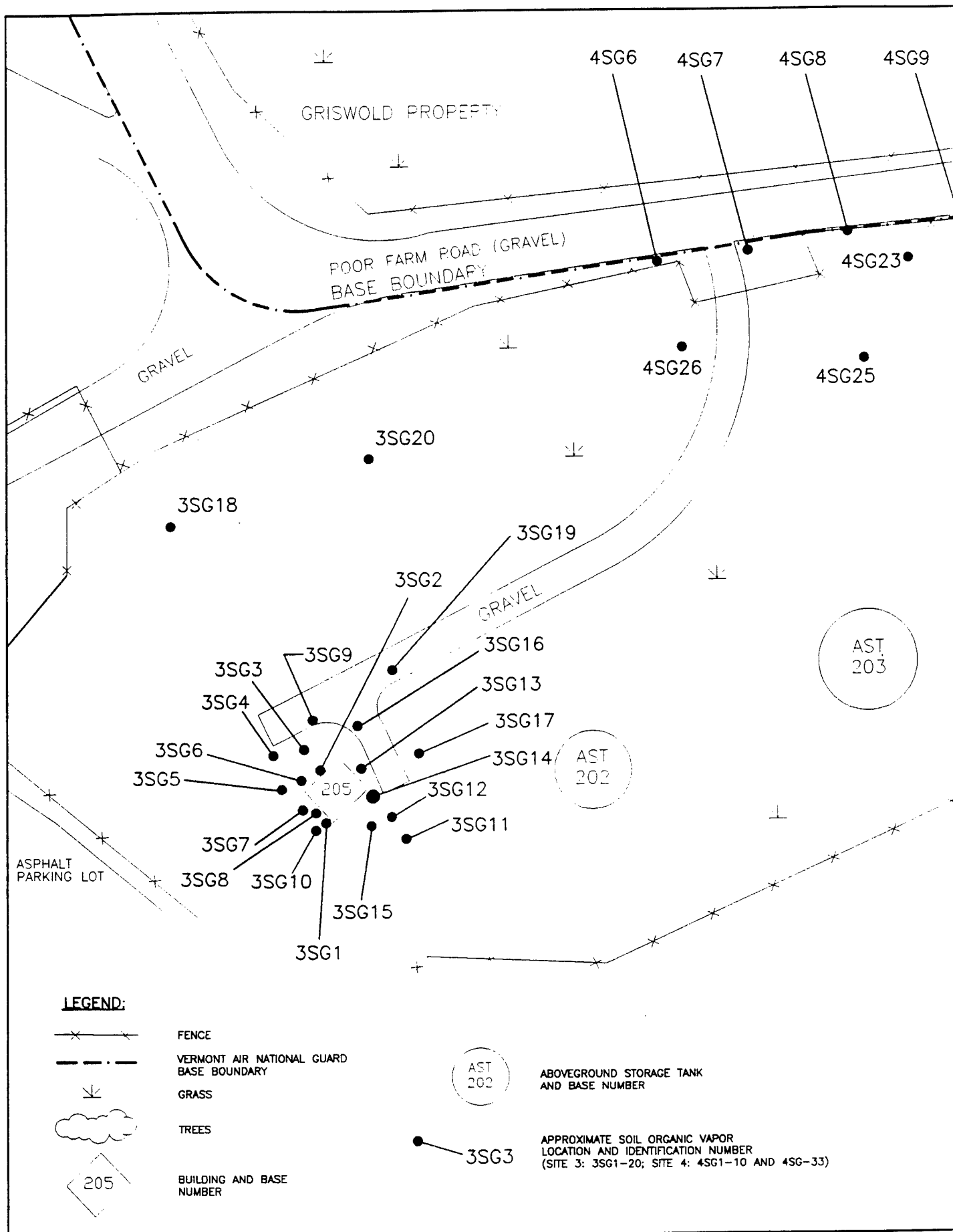
Fifty-three SOV locations were sampled during the ASI; 20 locations at Site 3 (3SG1 through 3SG20) and 33 locations at Site 4 (4SG1 through 4SG33) (Table 4-1). Sixty-one soil gas samples (excluding QA/QC samples) were collected and screened for target VOCs using an on-site GC; 21 samples from Site 3 and 40 samples from Site 4 (Table 4-2). SOV survey areas generally consisted of modified grid patterns, with locations spaced from less than 10 ft to greater than 50 ft apart. SOV survey locations were modified locally according to limiting site conditions, such as topography and locations of utilities, buildings, trees, fences, etc. SOV survey locations were labelled according to the following information: IRP Site Number (3 or 4), location type - soil gas (SG), and location type sequential number (e.g., 3SG1). SOV survey locations for Sites 3 and 4 are presented in Figure 4-1.

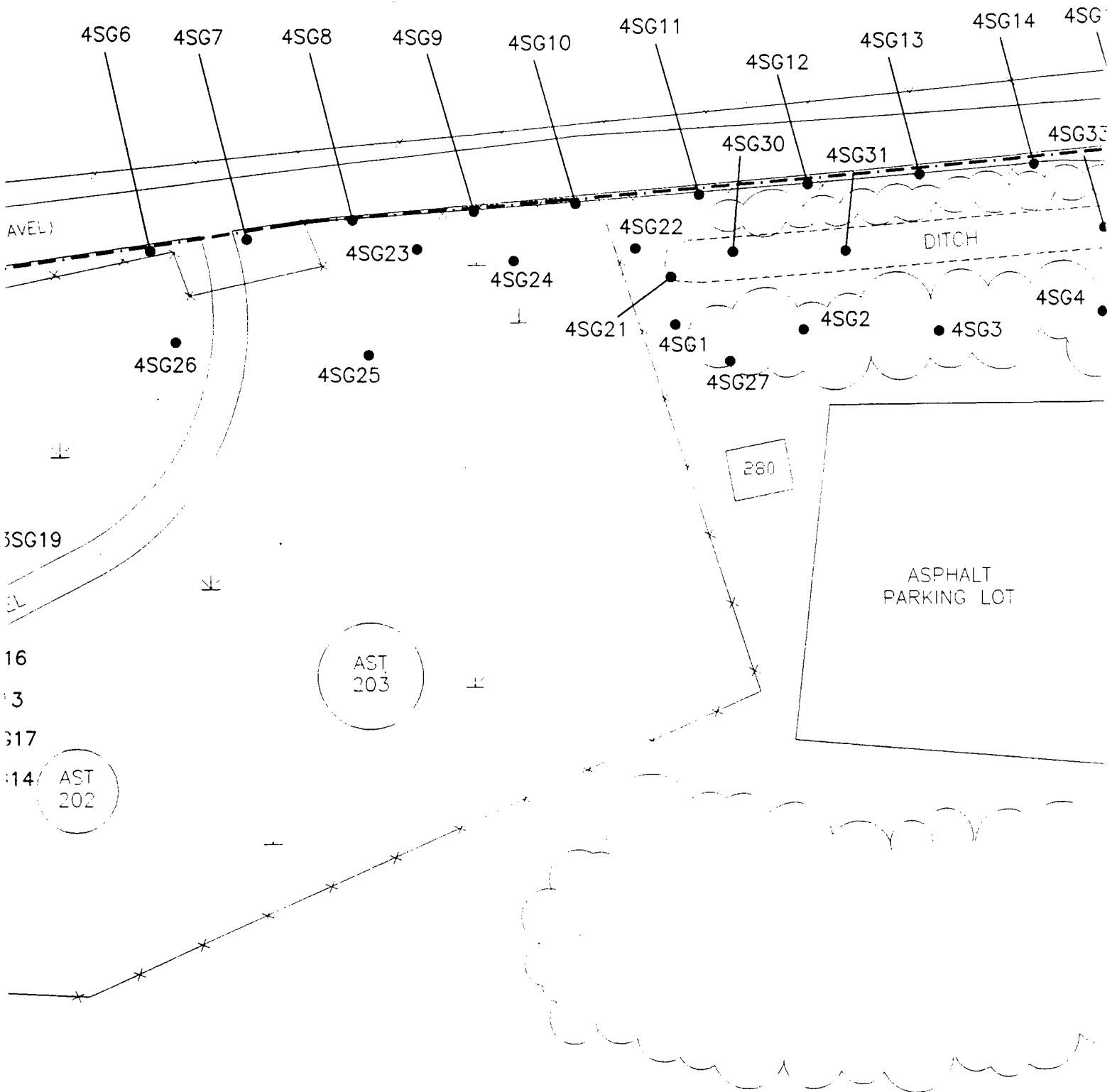
Soil gas samples were collected using a vacuum removal system. Soil gas samples were collected from subsurface sample depths using 0.5-inch inner diameter (ID) hardened steel sampling probes attached to various lengths of steel rod assemblies. The sampling probes were pushed or hydraulically hammered to depths ranging from 4 to 20 ft bgs. Five vertical profiles of soil gas were performed to determine optimal sampling depths across each site; one at Site 3 and 4 at Site 4. Vertical profiles consisted of soil gas samples collected every five feet, either from 5 to 15 ft bgs or 5 to 10 ft bgs. Once a sample probe was advanced to the desired sampling depth, dedicated polypropylene tubing was attached to the lead rod via a threaded sample cap and fitted with an o-ring to prevent vacuum leakage. The dedicated polypropylene sample line was then attached to a vacuum pump system located in the probe truck. Soil gas was pulled by the vacuum pump into the probe and tubing. A minimum of three tubing container volumes (approximately 2 liters per 3 tubing volumes) were purged before a sample was collected in one 250 milliliter (ml) glass sample bulb with Teflon® stopcocks. Once filled, the sample bulb was hand-delivered immediately to the on-site GC laboratory. A gas-tight glass syringe, inserted through a Teflon® septum on the sample bulb, was used to extract a soil gas sample, which was then injected directly into the GC for analyses. The estimated time from sample extraction to GC injection was usually less than one to two hours.

SOV survey results are discussed and presented in Section 5.0, Field Investigation Results. All SOV survey analytical data are presented in Appendix B.

4.2.2 Groundwater Screening/Temporary Piezometer Installation

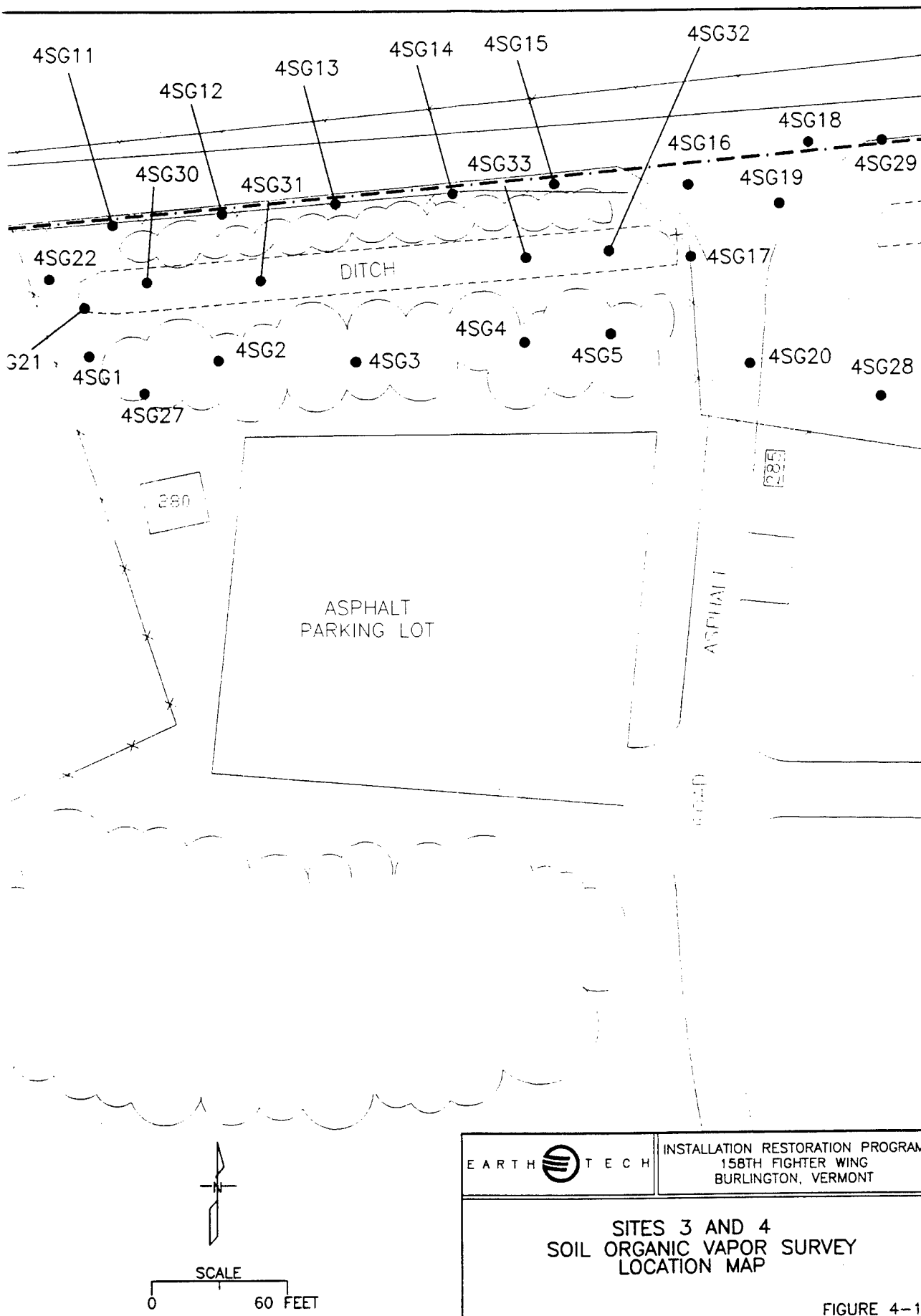
Eighteen groundwater screening locations were sampled and analyzed for target VOCs using an on-site GC; eight samples from Site 3 (3GW1 through 3GW8) and ten samples from Site 4 (4GW1 through 4GW10) (Tables 4-1 and 4-2). Some groundwater screening locations were located in SOV survey locations. Temporary piezometers, consisting of groundwater screening equipment, were installed in three soil gas locations in Site 4 (4PZ1 in 4SG5, 4PZ2 in 4SG15, and 4PZ3 in 4SG8) (Table 4-1). Each piezometer was left in place for approximately 24 hours or less, in an effort to characterize the local water table surface and groundwater flow direction. Groundwater screening/temporary piezometer locations were selected in the field, based in part on preliminary SOV survey results. Groundwater samples were collected near or below the water table from depths ranging from 16.5 to 30 ft bgs. Groundwater screening and temporary piezometer locations were labelled according to the





ABOVEGROUND STORAGE TANK
AND BASE NUMBER

APPROXIMATE SOIL ORGANIC VAPOR
LOCATION AND IDENTIFICATION NUMBER
(SITE 3: 3SG1-20; SITE 4: 4SG1-10 AND 4SG-33)



following information: IRP Site Number (3 or 4), location type - groundwater screening (GW) or temporary piezometer (PZ), and location type sequential number (e.g, 4GW1 and 4PZ1). Groundwater screening and temporary piezometer locations at Sites 3 and 4 are presented in Figure 4-2.

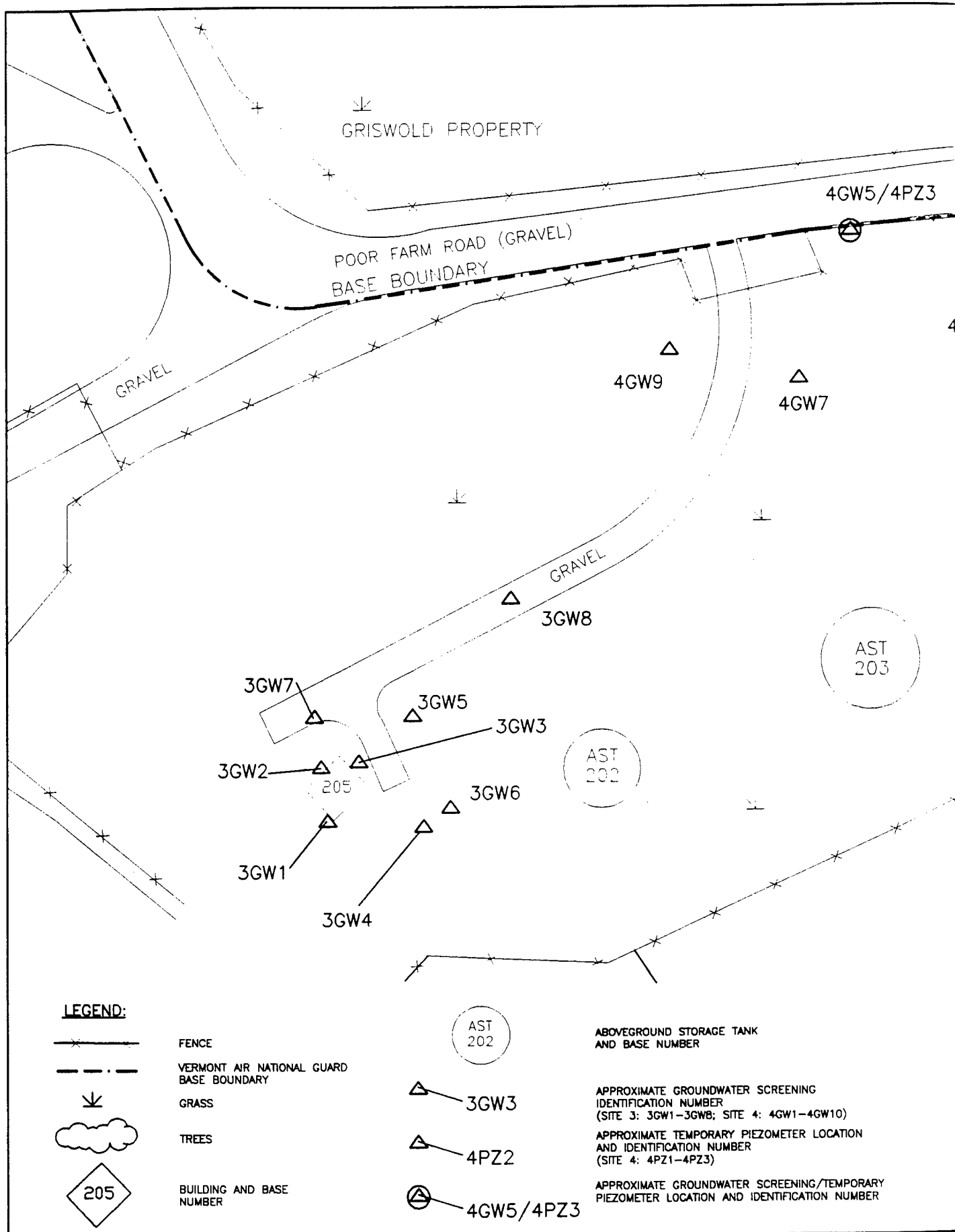
For groundwater screening/temporary piezometer locations, a pilot borehole was made by advancing rod and sample probe assemblies to desired sampling depths. Borings were advanced by using either a 1-inch OD probe rod or a 3-foot long, 0.75-inch OD, 0.01-inch slotted steel sample probe, fitted with detachable stainless steel drive-points. At some locations, water was sampled directly from steel rod/probe assemblies. At other locations, rod assemblies were removed from the boring, and 1/2-inch ID (3/4-inch OD) polyvinyl chloride (PVC) casing, with a 5-foot section of 0.01-inch slotted screen at the base, was temporarily installed for sampling. Groundwater screening samples were collected from both configurations using dedicated lengths of 3/8-inch OD polypropylene tubing fitted with a stainless steel check valve on the end. The sample tubing was discarded between locations, but the check valves were decontaminated between locations and reused. The tubing and check valve assembly functioned as an inertial pump. The tubing was raised and lowered, forcing groundwater past the inlet only check valve until it exited at the surface. This pumping method introduced no air to groundwater samples, which could have potentially compromised the representativeness of VOC analyses. Each water sample was collected in one completely filled 40-ml glass vial capped with a Teflon® septum cap. Samples were immediately hand-delivered to the on-site GC for analyses. At the GC field laboratory, 10 mls were decanted from each vial, the decanted vial was shaken vigorously for approximately one minute and heated at 90°C for 30 minutes, and a headspace sample was collected using a gas-tight glass syringe. The groundwater headspace sample was then injected directly into the GC for analyses.

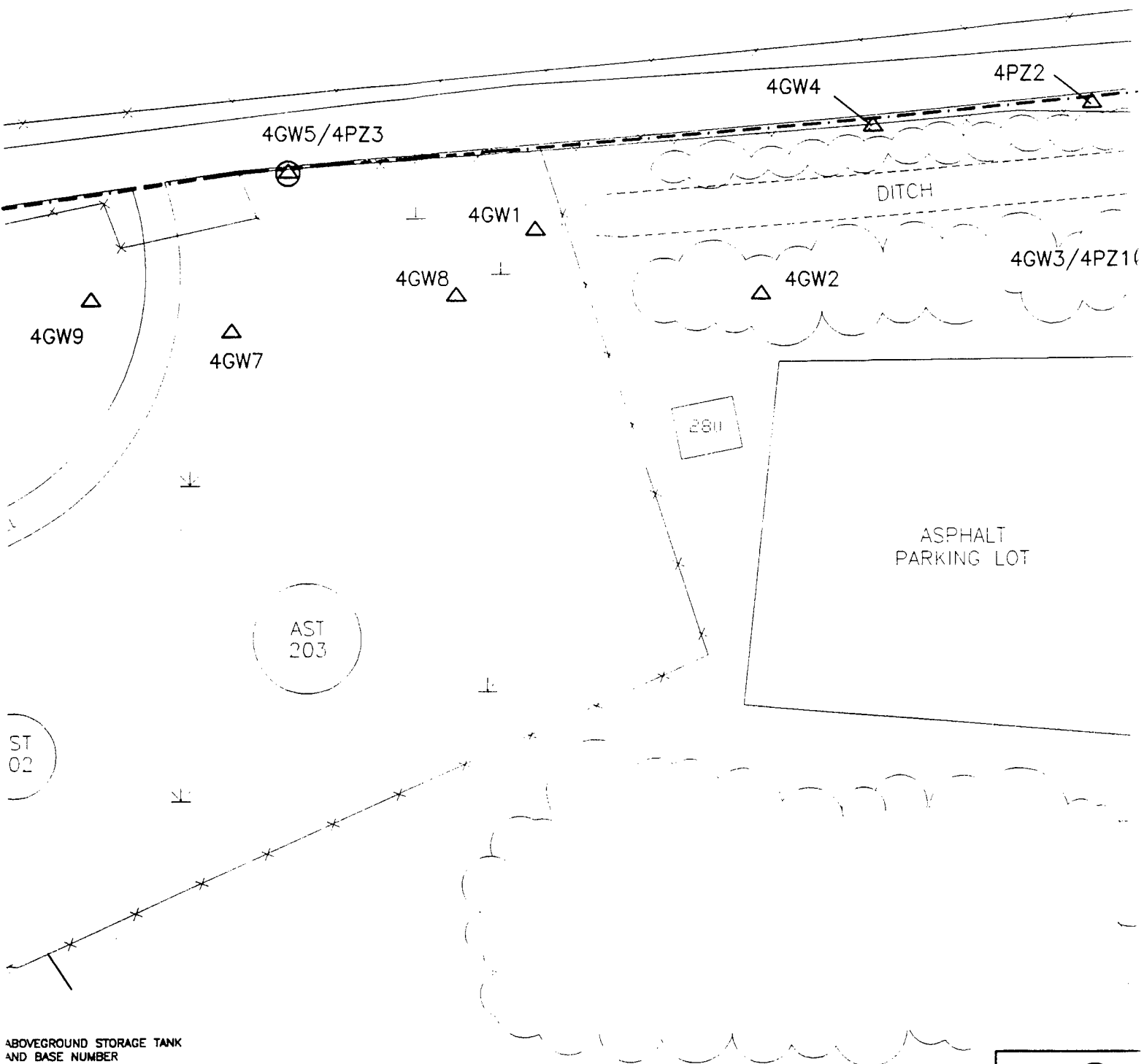
Groundwater screening results are discussed and presented in Section 5.0, Field Investigation Results. All groundwater screening analytical data and temporary piezometer water level data are presented in Appendix B.

4.2.3 Field Screening QA/QC Sampling

Field screening QA/QC sampling for soil gas and groundwater screening sampling consisted of field or laboratory duplicates and laboratory or method blanks per HAZWRAP QC Level B protocols. Field screening QA/QC sampling and analyses are summarized in Table 4-2.

Field duplicates consisted of duplicate volumes of soil gas or groundwater screening samples (one 250 ml soil gas bulb or one 40-ml glass water sample vial), which were collected in the field prior to submittal to the on-site GC laboratory. Laboratory duplicates consisted of duplicates extracted in the field laboratory from non-field duplicate sample containers, when extra sample volumes had not been previously collected in the field. Field and laboratory duplicates were prepared for analyses as previously discussed for soil gas and groundwater screening samples. Both duplicates were collected and analyzed at a minimum frequency of one for every 10 soil gas or groundwater screening samples (10%) in an effort to check the precision of the analytical method. Eight soil gas duplicates were collected and analyzed for 61 soil gas samples; one field duplicate from Site 4, three laboratory duplicates from Site 3, and four laboratory duplicates from Site 4. Three groundwater screening duplicates were



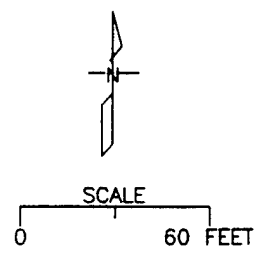


ABOVEGROUND STORAGE TANK
AND BASE NUMBER

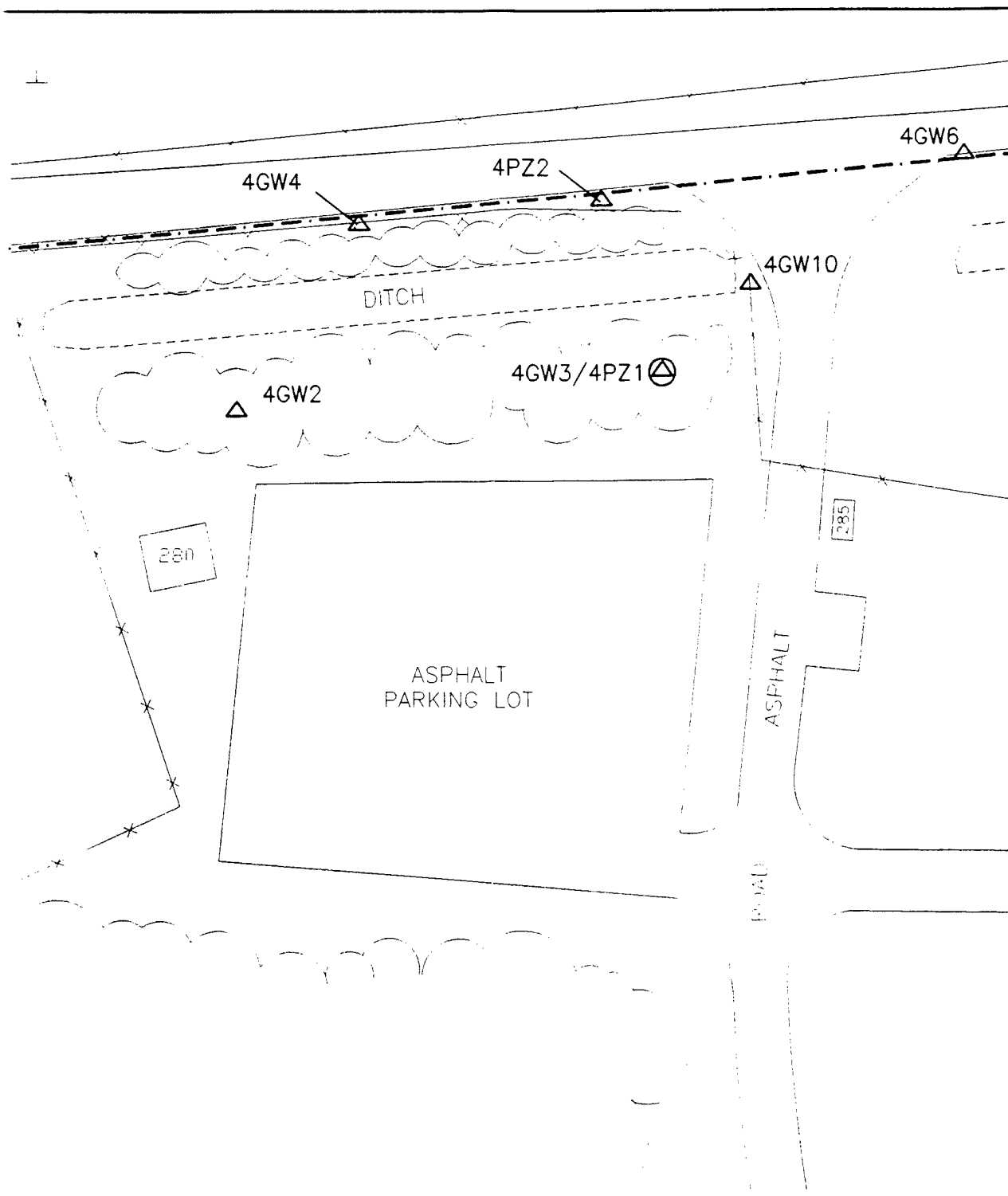
APPROXIMATE GROUNDWATER SCREENING
IDENTIFICATION NUMBER
(SITE 3: 3GW1-3GW8; SITE 4: 4GW1-4GW10)

APPROXIMATE TEMPORARY PIEZOMETER LOCATION
AND IDENTIFICATION NUMBER
(SITE 4: 4PZ1-4PZ3)

APPROXIMATE GROUNDWATER SCREENING/TEMPORARY
PIEZOMETER LOCATION AND IDENTIFICATION NUMBER



EARTH		T
GROUNDWATER PIEZ		



EARTH  TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
BURLINGTON, VERMONT

**SITES 3 AND 4
GROUNDWATER SCREENING AND TEMPORARY
PIEZOMETER LOCATION MAP**

FIGURE 4-2

3

4-9

collected and analyzed for 18 groundwater screening samples; one laboratory duplicate from Site 3, and two laboratory duplicates from Site 4. Field and laboratory duplicate analytical results for soil gas and groundwater screening samples are presented in Appendix B.

Laboratory or method blanks consisted of headspace blanks collected from one 250-ml glass soil gas bulb filled with ambient air and/or from one 40 ml glass vials filled with American Society of Testing and Materials (ASTM) Type I deionized (DI) water provided by the field laboratory. Soil gas method blanks of ambient air were collected using the vacuum removal system on an unused length of polypropylene tubing and a decontaminated soil gas sample probe. Groundwater screening method blanks were collected by pouring DI water over a decontaminated slotted well point. Headspace blanks were collected in gas-tight syringes, as previously discussed for each media, and injected into the GC for analyses. Media-specific blanks were collected and analyzed at the beginning of each day of media-specific sampling activities to check for the presence of contaminants in the sampling equipment and the analytical system. Laboratory or method blank analytical results were recorded in field laboratory logbooks, maintained by EnviroSurv.

4.2.4 Field Screening Analytical Methods

Soil gas and groundwater samples were analyzed for non-chlorinated and chlorinated target VOCs. Non-chlorinated target VOCs consisted of: benzene, toluene, ethylbenzene, and total xylenes (BTEX). Chlorinated target VOCs consisted of: 1,1-dichloroethene (DCE); trans-1,2 DCE; cis-1,2 DCE; 1,1,1 trichloroethane (TCA); trichloroethene (TCE), and tetrachloroethene (PCE). A semi-quantitative measurement of total VOCs detected on the flame-ionization detector (FID) of the GC was also recorded per sample.

All samples, soil gas and groundwater headspace, were analyzed on a Shimadzu 14A laboratory grade GC equipped with a FID and an electron capture detector. The GC was controlled by a CR4-AX integrating computer equipped with a 20 megabyte hard disk for method and data storage. The GC was calibrated for each target VOC using certified standards of BTEX gas and/or field prepared vapor or aqueous standards per HAZWRAP QC Level B protocols. Analytical results for soil gas and groundwater headspace samples were reported in milligrams per liter (mg/l) or parts per million (ppm). Target compounds and their GC detection limits for soil gas and groundwater headspace samples and further details regarding field GC methodologies and analytical results are included in Appendix B. Daily documentation of laboratory calibration, analytical, and QA/QC procedures were recorded in field laboratory logbooks, maintained by EnviroSurv.

4.2.5 Field Screening Boring Abandonment

Field screening borings include all borings advanced for soil gas or groundwater sampling and temporary piezometer installation. All field screening borings, typically 1-inch or less in diameter, were backfilled with hydrated granular bentonite. Four locations, overlain by asphalt in the eastern portion of Site 4, were additionally topped with concrete.

4.2.6 Field Screening Equipment Decontamination

Field screening equipment decontamination consisted of cleaning sample rods, probes, and stainless steel check valves between samples/locations. The decontamination of sampling equipment was conducted according to the following procedure: non-phosphate laboratory-grade detergent (Liqui-nox®) and potable water scrub and wash, a potable water rinse, an ASTM Type I DI water rinse, and air drying. All decontamination-derived fluids were contained. Decontamination was conducted in plastic buckets (typically, one for equipment wash and one for equipment rinse) underlain by plastic sheeting.

4.2.7 Field Screening Waste Handling

Field screening derived wastes were limited to decontamination procedure fluids and leftover groundwater screening sample volumes. Wastewater volumes were minor (less than 50 gallons), and were contained and transferred to a 1300-gallon polyethylene storage tank, previously staged on-site. The storage tank was subsequently used for holding confirmation activity-derived wastes. Final characterization and disposal of the resulting wastewater are discussed in Section 4.3.11. Miscellaneous field screening-derived waste, such as used polypropylene tubing, plastic sheeting, empty sample containers, latex or nitrile gloves, paper towels, etc., were not considered hazardous and were disposed of on-site in base trash dumpsters.

4.3 CONFIRMATION ACTIVITIES

ASI confirmation activities at IRP Sites 3 and 4 were conducted to confirm or deny the presence of fuel related contamination in site soils and groundwater and to characterize site geologic and hydrogeologic conditions. Confirmation activities at Sites 3 and 4 primarily consisted of soil borings and soil sampling, with soil sample analyses at an off-site laboratory, installation and development of groundwater monitoring wells, groundwater sampling, with analyses at an off-site laboratory, and water level and free-product measurements in background and site monitoring wells. Confirmation activities conducted at Site 4 also included surface water and sediment sampling, with analyses at an off-site laboratory.

The following confirmation activities were performed at Sites 3 and 4:

- Eleven site soil borings, including two optionals, were drilled and sampled for subsurface soils; five at Site 3 and six at Site 4.
- Six site groundwater monitoring wells were installed; three at Site 3 and three at Site 4 (one Site 4 well was installed in a soil boring).
- Two background soil borings/monitoring wells were drilled and sampled/installed; one at Site 3 and one at Site 4.
- Seventy-three split-spoon subsurface soil samples were collected for lithologic analyses and possible laboratory analyses; 21 from Site 3, and 34 from Site 4, and 18 from background locations.

- Thirty subsurface soil samples were submitted for laboratory analyses; 11 from Site 3, 13 from Site 4, and six from background locations.
- One round of groundwater samples was collected from six monitoring wells, and samples were submitted for laboratory analyses; two site wells at both Site 3 and Site 4 (one well per site was not sampled due to the presence of free-product), and two background wells.
- Three surface sediment samples and 1 surface water sample were collected from Site 4 and submitted for laboratory analyses.
- Two rounds of water level and free-product measurements were conducted at background and site monitoring wells; three wells at Site 3, three wells at Site 4, and two background wells.

According to the ASI WP (EARTH TECH 1994b), proposed confirmation activities at IRP Sites 3 and 4 included two rounds of groundwater sampling and aquifer characterization (two slug tests per site). These confirmation activities were omitted from the ASI, with the exception of the one round of groundwater sampling, based on the agreement of EARTH TECH, HAZWRAP, and the ANGRC that they would be implemented within subsequent interim remedial actions. This change in the field program enabled timely completion of the ASI. This field program change is documented on FCR Number 2, presented in Appendix A.

Confirmation activity sample collection and laboratory analyses were conducted according to HAZWRAP QC Level C protocols as stated in "Requirements for Quality Control of Analytical data" (DOE/HWP-65RI 1990a) and in "Quality Control Requirements for Field Methods" (DOE/HWP-69RI 1990b), and presented in the SRI SAP (EARTH TECH 1994c). HAZWRAP Level C corresponds to U.S. EPA DQO Level III, as stated in "Data Quality Objectives for Remedial Response Activities Development Process," OSWER Directive 93550-7B, March 1987 (EPA 1987).

Site H&S supervision was conducted by EARTH TECH as specified in the SRI SAP (EARTH TECH 1994c). All confirmation activities were conducted in PPE Level D. Ambient air in the vicinity of borings and work area breathing zones was monitored for the presence of organic vapors, using an OVM, and for lower explosivity level (LEL) and oxygen (O₂) content using an LEL/O₂ meter.

Confirmation activities were conducted in September and October 1994. Parratt Wolff, Incorporated of East Syracuse, New York (Parratt Wolff), subcontracted by EARTH TECH, conducted soil boring, soil sampling, and monitoring well installation and development activities at IRP Sites 3 and 4. EARTH TECH supervised all drilling, soil sampling, and well installation and development activities, and conducted all sampling for laboratory analyses. In October 1994, EARTH TECH conducted one round of groundwater and surface water and sediment sampling. CompuChem Environmental Corporation of Chapel Hill, North Carolina (CompuChem) analyzed all samples submitted for laboratory analyses. Laboratory analyses included VOCs, semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), and Target Analyte List (TAL) metals. All confirmation laboratory analytical results and chain of custody (COC) forms are presented in Appendix J.

Daily confirmation activities were documented by EARTH TECH in field logbooks and summarized in the Site Logbook. Field equipment calibration (OVM, LEL/O₂, and water parameter meters) was documented in the Field Equipment Calibration Logbook. Specific confirmation activities also were documented on applicable field logs; boring logs, monitoring well installation logs, monitoring well development logs, monitoring well purging logs, monitoring well sampling logs, and surface water and sediment sampling logs. All confirmation activity field logs are presented in Appendix C.

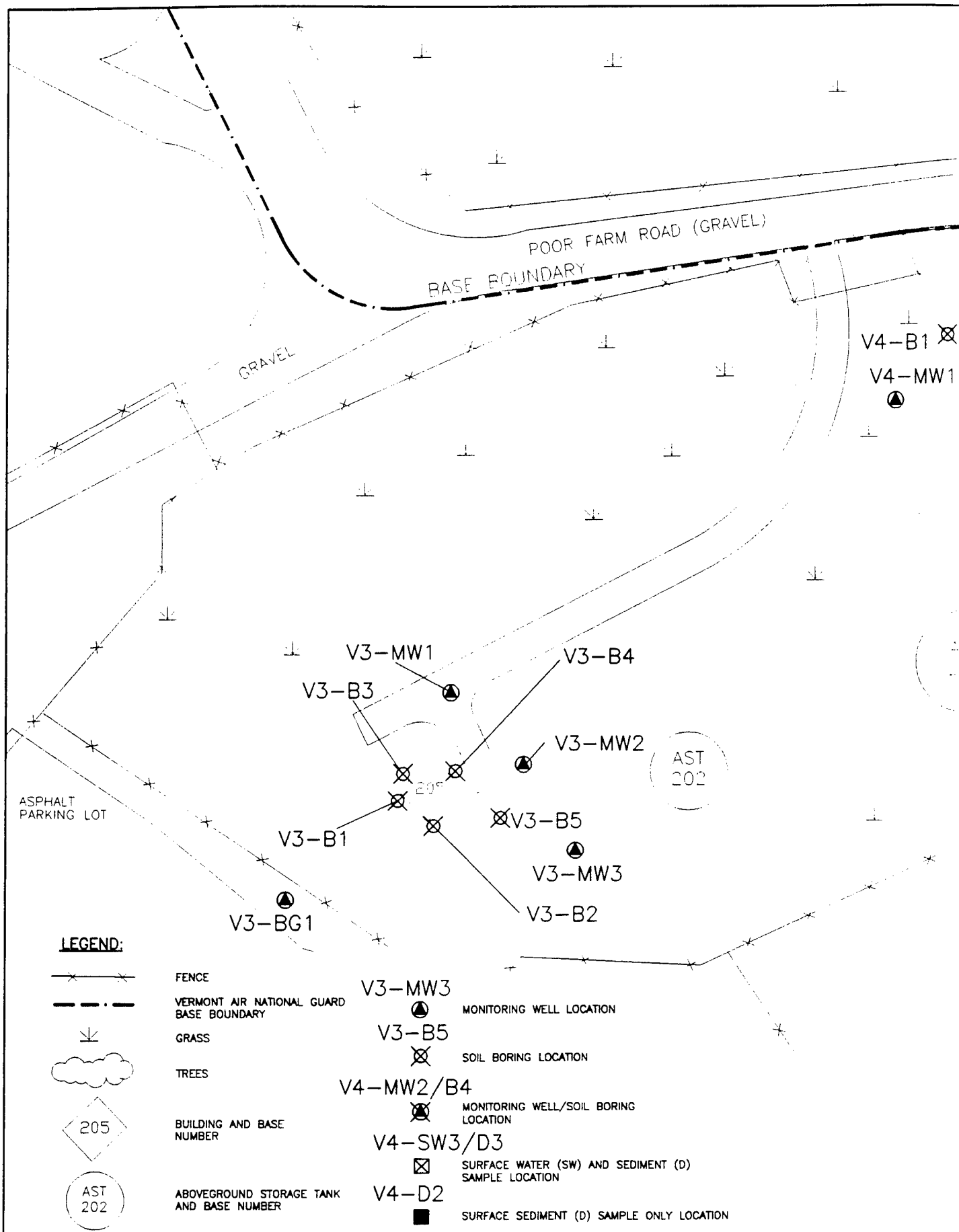
Specific confirmation activity procedures, including soil boring and subsurface soil sampling, surface sediment sampling, groundwater monitoring well installation and development, water level and free-product measurement, groundwater sampling, surface water sampling, QA/QC sampling, laboratory analytical methods, boring abandonment, decontamination, waste handling, and surveying, are discussed in the following sections.

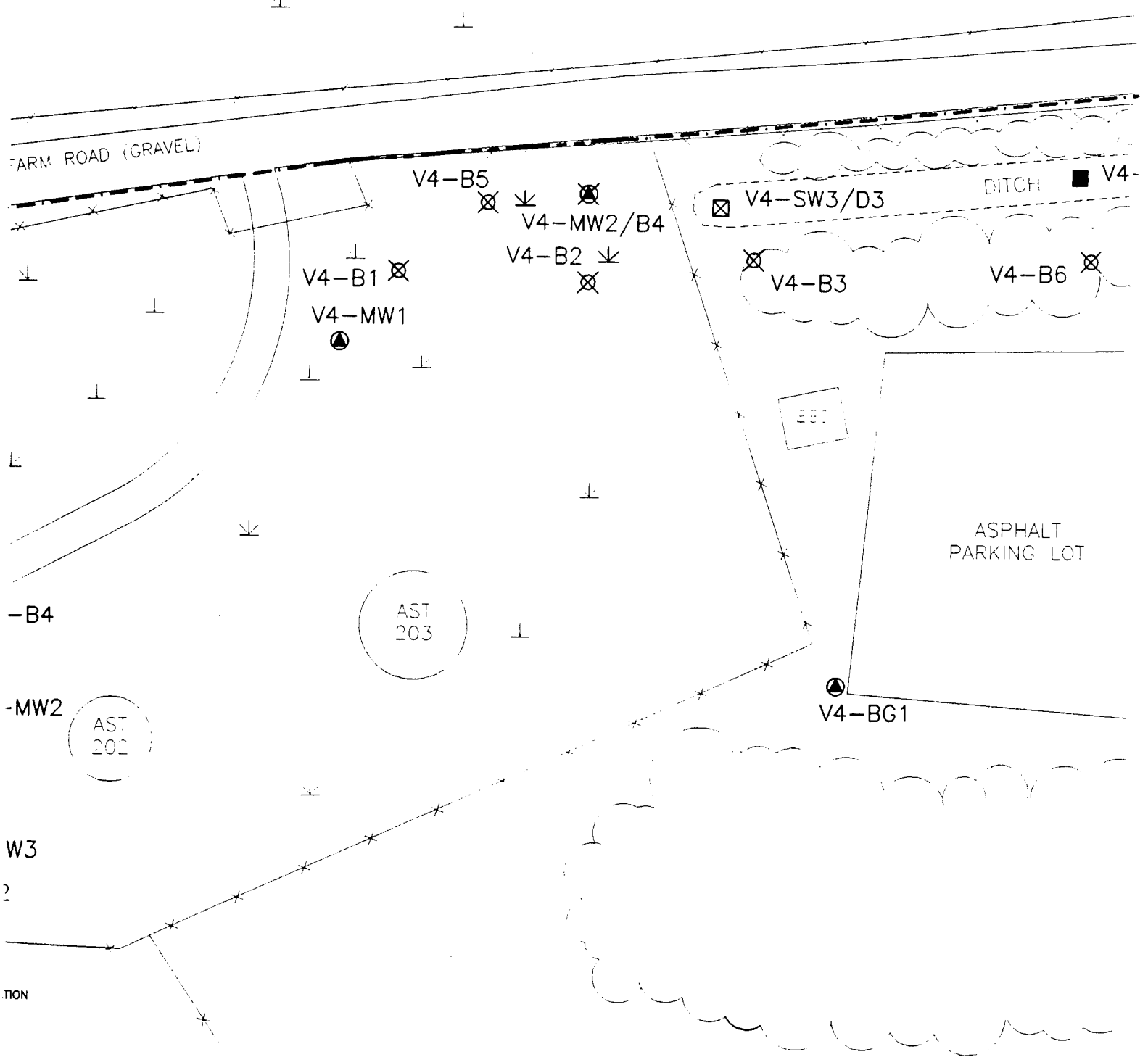
4.3.1 Soil Boring and Subsurface Soil Sampling

Eleven soil borings were drilled for subsurface soil sampling; five borings at Site 3 (V3-B1 through V3-B5) and six borings at Site 4 (V4-B1 through V4-B6) (Table 4-1). One optional soil boring was utilized at each site per HAZWRAP and ANGRC approval. All soil borings were generally drilled and sampled to the water table. Six soil borings were drilled for groundwater monitoring well installation; three locations at Site 3 (V3-MW1 through V3-MW3) and three locations at Site 4 (V4-MW1 through V4-MW3) (Table 4-1). Two background soil borings were drilled for subsurface soil sampling and groundwater monitoring well installation; one at Site 3 (V3-BG1) and one at Site 4 (V4-BG1) (Table 4-1). Except for the two background soil boring/monitoring well locations and soil boring V4-B4 in Site 4, monitoring well locations were sampled for lithologic analyses only. Soil boring V4-B4 was utilized for the installation of monitoring well V4-MW2 per HAZWRAP and ANGRC approval, due to limited drilling access at locations further hydraulically downgradient of apparent soil and groundwater contamination. Drilling access was limited by site topography and the location of overhead electric power lines. Soil borings and monitoring wells were labelled according to the following information: 1) base identifier - Vermont ANG Base (V) and IRP Site Number (3 or 4); 2) location type - soil boring (B), monitoring well (MW), or background soil boring/monitoring well (BG); and 3) location type sequential number (e.g., V3-B1 and V3-MW1). Soil boring, monitoring well, and background soil boring/monitoring well locations for Sites 3 and 4 are presented in Figure 4-3.

Seventy-three subsurface soil samples were collected for lithologic and possible laboratory analyses; 35 from Site 3 and 38 from Site 4 (Table 4-1). Total depths (TDs) ranged from 13 to 70 ft bgs at Site 3 and from 19 to 95 ft bgs at Site 4. Thirty subsurface soil samples (excluding extra sample volumes for QA/QC duplicates) were subsequently submitted for laboratory analyses; 11 from Site 3, 13 from Site 4, and six from background locations (Table 4-3). Soil boring and subsurface soil sampling procedures are presented in the following discussion.

All soil borings were drilled using a Central Mining Equipment (CME)[®]-75 truck-mounted drilling rig with continuous-flight 4.25-inch ID hollow-stem auger assemblies. Soil cuttings generated from the hollow-stem augers were staged on plastic sheeting at each soil boring location. Volumes of potable water were added to some borings to facilitate drilling and sampling in

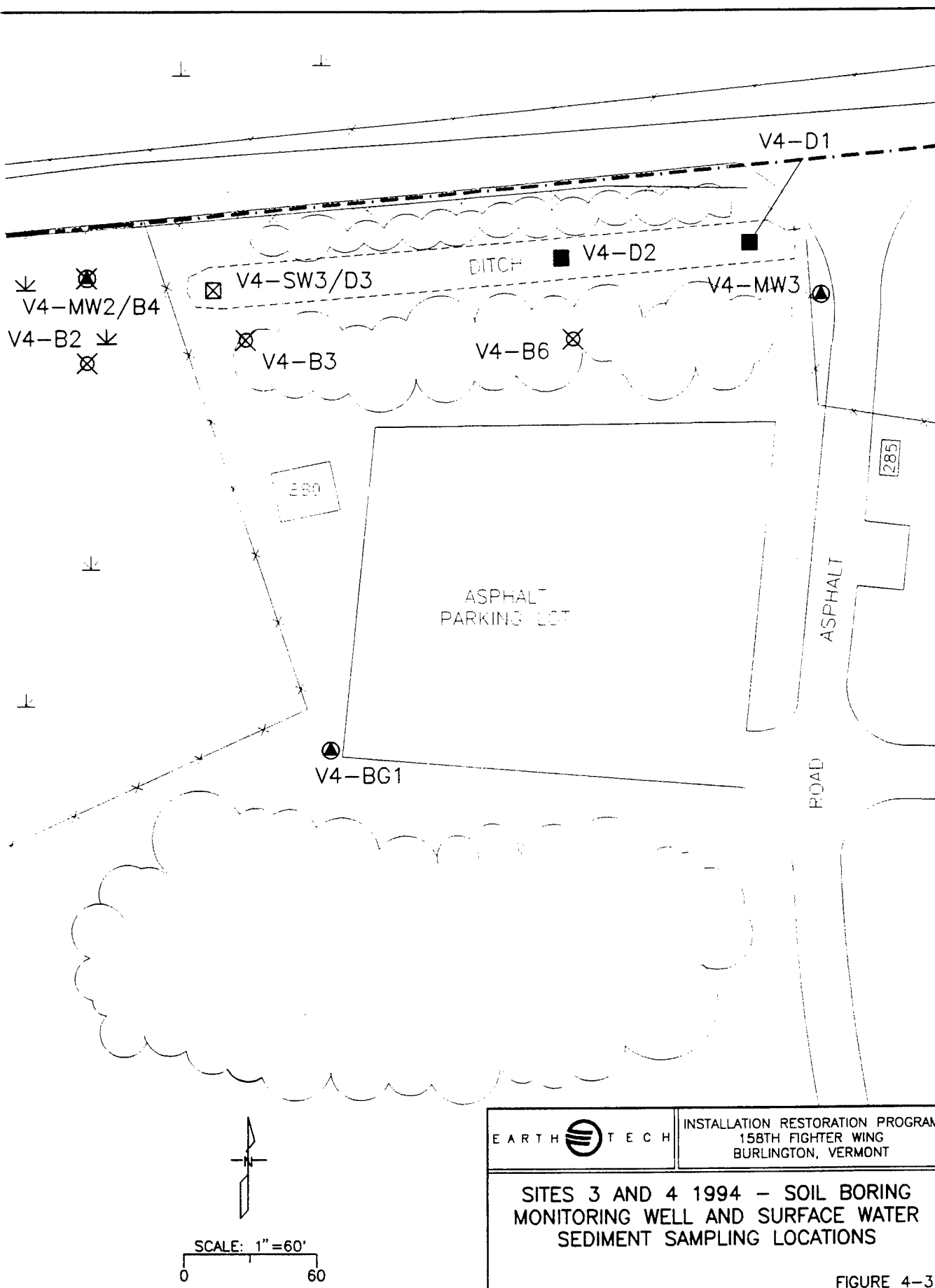




SCALE: 1"=60'

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saturated (heaving) sands and silt present at and below the water table. Added potable water volumes were recorded on boring logs and well installation logs. Drilling and sampling equipment were decontaminated between locations and sample intervals according to the procedures discussed in Section 4.3.10.

Subsurface soil sampling was conducted using 2-foot long, 2-inch OD carbon steel split-spoon samplers lined with 1.5-inch OD stainless steel sample liners; typically four 6-inch long liners or three 6-inch liners and one 4.75-inch long liner. Samples were collected at selected intervals, in advance of the hollow-stem augers, by driving each sampler into undisturbed soil using a drilling rig-mounted 140 pound hydraulic hammer and carbon steel sample rod assembly. Hammer blow counts for each 6-inch interval of split-spoon advance were recorded during drilling. Generally split-spoon samples were collected every five feet, from shallow subsurface depths (approximately 3-5 ft bgs) to depths proximal to the water table (approximately 15-20 ft bgs). Once the split-spoon sampler was advanced across a 2-foot sample interval, or until spoon refusal was encountered, the split-spoon was retrieved and opened in the presence of the EARTH TECH site geologist. Opened split-spoons were examined by the site geologist on dedicated sections of aluminum foil placed above ground level on a field work table. Split-spoons and sample liners were handled with dedicated nitrile gloves, to minimize the potential for cross-contamination. Immediately upon opening the split-spoon, the liners were split apart either by hand or by using a decontaminated stainless steel knife. The stainless steel knife was also used to cut open soils on liner ends for OVM PID scanning. The OVM probe was placed inside the soil cuts on each end of each liner, to minimize ambient air effects, and readings were noted. The highest readings from the upper, middle, and lower portions of the 2-foot sample interval were recorded in the field logbook and on the boring log. The lead liner, or the liner (within each split-spoon) exhibiting the highest OVM reading was selected for potential laboratory analyses for VOCs. An adjoining liner, adjacent to the liner end exhibiting the highest VOCs, was selected for potential laboratory analyses for SVOCs, TPH, and TAL metals. Additional volumes for non-VOC QA/QC samples [field duplicates or matrix spike and matrix spike duplicates (MS/MSDs)] were provided with the next adjoining liner. Split samples for the Vermont HMMD were collected by submitting the liner next to the lead liner for VOCs analyses and the uppermost liner for SVOCs, TPH, and TAL metals analyses. Each sample liner was capped with Teflon® tape and covered with a tightly fitting polyethylene endcap. The liner selected for VOCs was capped first to prevent VOC loss. All soil samples were labelled and stored in an iced cooler, containing a trip blank, at approximately 4°C, until selection of samples for laboratory analyses. Soil samples were collected per sample preservation requirements listed in Table 4-4.

Remaining sample volumes per split-spoon, typically one to two liners, were used for lithologic descriptions, and, for the first four soil borings (V4-B2, V4-B3, V4-B4, and V4-B6), VOC headspace analyses. VOC headspace analyses consisted of emptying one liner volume of soil into a clean 8-ounce glass jar, covering the top with aluminum foil, shaking the container, and checking the resulting headspace with the OVM after approximately 15 minutes. For some sample intervals, filled and capped headspace containers were stored near the heater vents of the EARTH TECH field van, in an effort to increase volatilization (at temperatures greater than 70°F. For other sample intervals, the containers were stored under ambient air temperatures (typically 60-70°F). Comparison of VOC headspace results with PID liner scanning results consistently indicated higher VOC readings from initial PID scanning of liner ends. Therefore, selection of samples submitted for laboratory analyses was based in part on

Table 4-4 Laboratory Analytical Sample Collection and Preservation Summary
Vermont Air National Guard Base

Analysis	Sample Media	Analytical Method	Sample Container	Volume Collected	Sample Preservation	Sample pH	Sample Holding Time
VOCs ¹	Soil	Methods 8010/8020 ¹	SS Liner	6.6 oz	4°C	--	14 Days Analysis
VOCs ¹	Water	Methods 8010/8020 ¹	Glass	(2) 40ml	4°C, HCL	<2	14 Days Analysis
SVOCs ²	Soil	CLP (3/90) ²	SS Liner	*	4°C	--	14 Days Extraction/ 40 Days Analysis
SVOCs ²	Water	CLP (10/92) ²	Glass Amber	1 liter	4°C	--	7 Days Extraction/ 40 Days Analysis
TPH ³	Soil	Mod. Method 8015 ³	SS Liner	*	4°C	--	14 Days Extraction/ 40 Days Analysis
TPH ³	Water	Mod. Method 8015 ³	Glass Glass Amber	(2) 40 ml liter	4°C, HCL 4°C	<2 --	14 Days Extraction/ 40 Days Analysis
TAL Metals ⁴	Soil	CLP (3/90) ⁴	SS Liner	*	4°C	--	6 Months Analysis (28 Days Mercury)
TAL Metals ⁴	Water	CLP (3/90) ⁴	Plastic	1 liter	HNO ₃	<2	6 Months Analysis (28 Days Mercury)

¹ VOCs - Volatile Organic Compounds analyzed by Methods 8010/8020, as stated in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods," U.S. Environmental Protection Agency (EPA) SW-846, 3rd Edition, November 1986.

² SVOCs - Semivolatile Organic Compounds analyzed by Contract Laboratory Program (CLP) Methods, as stated in "EPA CLP, Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration," March 1990 (3/90) Revision for soils and October 1992 (10/92) Revision for waters.

³ TPH - Total Petroleum Hydrocarbons analyzed by California Modified Method 8015, as stated in "Leaking Underground Fuel Tank (LUFT) Field Manual," State Water Resources Control Board, State of California, May 1988.

⁴ TAL Methods - Target Analyte List Metals analyzed by CLP Methods, as stated in "EPA CLP, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 3/90 Revision for soils and waters.

* Soil Samples for SVOC, TPH, and TAL Metals analysis were collected and submitted in (1) 6-inch long x 1/5-inch outer diameter stainless steel liner (approximately 6.6 oz. or less/liner).

SS Stainless Steel

ml Milliliters

oz ounces

°C degrees centigrade

HCL hydrochloric acid

HNO₃ nitric acid

PID scanning results, rather than VOC headspace readings. Based on these findings, and following verbal approval from HAZWRAP, VOC headspace analysis was discontinued. This change was documented on FCR Form No. 3. Soil boring-specific geologic and hydrogeologic data were recorded on boring logs and in field logbooks. Lithologic descriptions of split-spoon samples and soil cuttings were logged according to the Unified Soil Classifications System (USCS), and Munsell® Color Chart colors for soil (Munsell® 1990) or rock (GSA 1991). Subsurface soil sample intervals, and sample intervals submitted for laboratory analyses, are indicated on each boring log. Boring log and field logbook information included driller's observations on subsurface lithologies (e.g., drilling rates) and the apparent depth to the water table, based on wet downhole drilling or sampling equipment and direct measurement using a water level indicator. Boring logs are presented in Appendix C.

Two to three sample intervals per boring were submitted for laboratory analyses, in an effort to characterize the presence of contamination from shallow to subsurface depths (less than 5 ft bgs) to the water table (17-24 ft bgs). Typically, selected samples consisted of the sample nearest the water table and the sample nearest the surface. If applicable, an additional sample exhibiting the highest OVM reading was also submitted. Following lithologic and VOC headspace analyses, remaining sample volumes per split-spoon were returned to sample cuttings staged at boring locations.

Soil samples submitted for laboratory analyses were labelled according to the following information: 1) base identifier - Vermont ANG Base (V) and IRP Site Number (3- or 4-); 2) location type - soil boring (B) or background soil boring/monitoring well (BG) and sequential number; and 3) four digit sample interval in ft bgs, such as 10-12 ft bgs (1012) (e.g., V3-B1-0305). Additional volumes submitted for QA/QC duplicates were indicated by adding additional qualifiers; field duplicate (-D) or matrix spike/matrix spike duplicate (-QA/QC). QA/QC samples are discussed further in Section 2.2.7. Soil samples were shipped for laboratory analyses according to the shipping and COC procedures presented in the SRI SAP (EARTH TECH 1994c).

Soil boring and subsurface soil sampling results, including site geologic and hydrogeologic conditions and laboratory analytical results, are discussed and presented in Section 5.0, Field Investigation Results. All subsurface soil laboratory analytical data, and COC Forms, are presented in Appendix J.

4.3.2 Groundwater Monitoring Well Installation and Development

The procedures used for groundwater monitoring well installation and development are included in the following sections.

4.3.2.1 Monitoring Well Installation

Optimal groundwater monitoring well locations were determined based on field screening results, and preliminary confirmation soil boring results. Eight groundwater monitoring wells were installed during the ASI; three at Site 3 (V3-MW1 through V3-MW3), three at Site 4 (V4-MW1 through V4-MW3), and two in background locations (V3-BG1 and V4-BG1) (Table 4-1). All wells were installed across the water table in areas hydraulically downgradient of suspected source areas, with TDs of installation ranging from 24 to 50 ft bgs. Monitoring

well labelling is discussed in Section 4.3.1. Monitoring well installation activities were recorded on monitoring well construction logs and in field logbooks. Monitoring well locations are presented in Figure 4-3. Monitoring well construction logs are presented in Appendix C.

All monitoring wells were installed through 4.25-inch ID hollow-stem auger assemblies to prevent loss of borehole and collapse of sediments against well casing materials. All wells were installed using 10-foot sections of Diedrich® 2-inch nominal ID, Schedule 40 PVC casing; riser and 0.01-inch slotted screen. PVC endcaps of either 0.3- or 0.04-foot lengths were added to each lead screen section.

Well casing materials were shipped to the site in original plastic liners. Well casing materials present on-site in broken plastic liners were steam cleaned prior to installation. Ten feet of screen were installed in each well, typically with 3 to 4 ft of screen placed above the water table, in order to monitor for the presence of free product. Well casing materials were measured prior to installation for determination of total well depth. Prior to or after downhole placement of well casing, filterpack material was added to the well boring. Filterpack or sandpack material consisted of Morie® Number 0 Mesh (medium grained) silica sand. The sandpack was added by slowly pouring from 50-pound (lb) bags, and checking for depth of placement with a decontaminated tape measure. The auger assembly was incrementally pulled up, following placement of several ft of sandpack in the lead auger ID, to prevent (or minimize) collapse of the boring sediments against the well casing. Sandpack was added to a depth of 2-3 ft above the top of the screen, to prevent (or minimize) the potential for migration of annular seal materials to the well screen. The sandpack was topped with an annular seal of approximately 3 ft of hydrated bentonite. Approximately 50 to 75 lbs of Enviroplug® Medium Bentonite Chips were added per well, and hydrated for approximately 30 minutes with approximately 6-7 gallons of potable water. Following hydration of the bentonite chips, the remaining open annulus was sealed with bentonite grout. A high solids grout (approximately 9.4 lbs/gallon), made by mixing Wyo-Ben® granular bentonite with potable water, was pressure-tremied from the top of the hydrated bentonite chips to approximately 2-3 ft bgs. An all bentonite annular grout was used instead of a cement-bentonite grout to minimize the potential for the downward migration of high pH cement material to the well screen and its subsequent effect on local groundwater chemistry. This change was documented on FCR Form No. 4, presented in Appendix A.

All monitoring wells were completed as flush-mount installations, with 8-inch OD by 8-inch long metal flush "boxes" set in 2-foot OD by 0.5-foot thick cement pads. Each flush "box" annulus was connected to shallow subsurface soils by leaving the top of annular grout below the depth of the "box", minimizing the potential for surface water to fill the flush "box" and submerge the top of the well casing. Each well was secured with keyed-alike expandable locking well caps and bolted flush-mount lids.

4.3.2.2 Monitoring Well Development

After installation, seven of the eight ASI monitoring wells were developed to 1) remove fine-grained sediments from the filterpack, 2) open drilling-occluded porosity and permeability, restoring the natural hydraulic properties of the formation near the borehole, and 3) remove stagnant (non-formation) water from the filter pack and well casing ID. Monitoring well V3-MW2 in Site 3 was not developed due to the presence of free-product. Monitoring well

development activities were recorded on well development logs and in field logbooks. Well development logs are presented in Appendix C.

Upon opening each well cap, the well casing ID was checked for the presence of VOCs using an OVM. Prior to development, wells were checked for depth to water, total depth, and the presence of free product, using an ORS® oil/water interface probe. Well volumes, including filterpack volumes, were calculated. Well development was initiated following a minimum of 24 hours after installation of annular seals. Initially, a decontaminated plastic bailer and dedicated nylon cord were used to surge the well screen sections and develop the filterpack. Wells were then purged using a Whale® electric submersible pump and polyethylene tubing, and/or the plastic surge bailer. Wells were generally purged of 3 to 5 well volumes (consisting of filterpack and well casing ID volumes per well volume) and any volume of potable water added to the borehole/well during drilling and well installation activities. Purged well water was incrementally checked (per well volume) for pH, temperature, and conductivity using a Hydac® water parameter meter. Development proceeded until calculated well volumes had been purged, and until: 1) groundwater purged from the well became noticeably less turbid and the turbidity showed no signs of decreasing further; and 2) measurement of purge water pH, temperature and conductivity, recorded per purged well volume, remained stable within 10% for three consecutive measurements (well volumes). Color, turbidity, odor, and visible hydrocarbon sheen (if present) were also recorded per well volume.

All well development derived water was contained in plastic buckets and polyethylene tanks. Plastic sheeting was used to minimize spillage to the ground surface. All water removed during well development activities was transferred to large volume polyethylene tanks staged at IRP Site 1. Wastewater characterization and disposal is discussed in Section 4.3.11. Reusable well development equipment, including the electric submersible pump and polyethylene tubing, and the plastic bailer were decontaminated between locations according to the procedures presented in Section 4.3.10.

4.3.3 Water Level and Free-Product Measurement

Depth to water and free-product thickness (if present) were measured in each well during drilling, well installation, well development, and well purging and sampling activities, and in two rounds of water level and free-product measurements conducted October 5-6, 1994 and October 21-22, 1994 using a HAZCO® water level meter and/or an ORS® oil/water interface probe.

Depths to water and free-product (if applicable) were measured from a surveyed notch on the top the well casing. Measurements were recorded to the nearest 0.01 ft. Water level meters and oil/water interface probes were decontaminated between locations according to the procedures discussed in Section 4.3.10. All results were recorded on applicable field logs and field logbooks. Water level and free-product data are presented and discussed in Section 5.0, Field Investigation Results. Field logs are presented in Appendix C.

4.3.4 Groundwater Sampling

Groundwater samples from six monitoring wells were collected and submitted for laboratory analyses for VOCs, SVOCs, TPH, and TAL metals (Tables 2-1 and 2-3). Three monitoring

wells were sampled at Site 3 (V3-BG1, V3-MW1, and V3-MW3) and at Site 4 (V4-BG1, V4-MW2, and V4-MW3). Monitoring wells V3-MW2 and V4-MW1 were not purged and sampled due to the presence of free-product. Monitoring well purging and sampling activities were recorded in field logbooks and on monitoring well purging logs and monitoring well sampling logs. Monitoring well purging logs and monitoring well sampling logs are presented in Appendix C. Well purging and sampling activities were conducted according to the following procedures.

Following more than 24 hours after well development, monitoring wells were purged and then sampled for groundwater. Upon opening each well cap, the well casing ID was checked for the presence of VOCs using an OVM. Prior to purging, wells were checked for depth to water, total depth, and the presence of free product, using an ORS® oil/water interface probe. Well volumes, filterpack and well casing ID volumes, were calculated. Wells were then purged using a decontaminated Teflon® bailer and dedicated polypropylene cord. Wells were generally purged of 1 filterpack volume and 3 well casing ID volumes water. Purged well water was incrementally checked for pH, temperature, and conductivity using a Hydac® pH meter and an Orion® conductivity/temperature meter. Purging proceeded until a minimum of 1 filterpack volume and 3 well casing ID volumes had been purged, and until measurement of purged water pH, temperature, and conductivity, recorded per well volume, remained stable within 10% for three consecutive measurements. Color, turbidity, odor, and visible hydrocarbon sheen (if present) were also recorded per well volume.

Immediately following well purging (or within 24 hours of well purging for well V3-BG-1) groundwater samples were collected and preserved according to the specific requirements presented in Table 4-4. Samples were collected using dedicated nitrile gloves and the Teflon® bailer and polypropylene cord used for well purging. Samples were collected over plastic sheeting to prevent spillage and contact of the bailer and cord with the ground surface. VOCs were collected first, followed by (in order) the volumes required for SVOCs, TPH, and TAL metals. Total and dissolved (filtered) TAL metals were collected. Dissolved TAL metals samples were collected by positioning a disposable 0.45-micron pore size plastic filter on the end of the bailer and using a hand pump assembly to move the water through the bailer/filter assembly. Additional QA/QC volumes were collected as required per analyte. Split samples for the Vermont HMMD were collected per bailer per analysis.

Groundwater samples submitted for laboratory analyses were labelled according to the following information: 1) base identifier - Vermont ANG Base (V) and IRP Site Number (3- or 4-); 2) location type - background monitoring well (BG-) or monitoring well (MW); and 3) four digit date - month/year (1094) (e.g., V3-MW1-1094). Additional volumes submitted for QA/QC duplicates were indicated by adding additional qualifiers; field duplicate (-D) or matrix spike/matrix spike duplicate (-QA/QC). QA/QC samples are discussed further in Section 4.3.7. Groundwater samples were shipped for laboratory analyses according to the shipping and COC procedures presented in the SRI SAP (EARTH TECH 1994c).

All well purging and sampling-derived water was contained in plastic buckets and was subsequently transferred to a large volume polyethylene tank staged at IRP Site 1. Wastewater characterization and disposal is discussed in Section 4.3.11. Reusable purging and sampling equipment (Teflon® bailers and filter attachments) was decontaminated between sample locations according to the procedures presented in Section 4.3.10.

Groundwater sampling results, including laboratory analytical results, are discussed and presented in Section 5.0, Field Investigation Results. All groundwater sample laboratory analytical data, and COC Forms, are presented in Appendix J.

4.3.5 Surface Water Sampling

Surface water samples from one location (V4-SW3) of standing water in the open drainage ditch of the eastern portion of Site 4 were collected and submitted for laboratory analyses for VOCs, SVOCs, TPH, and TAL metals (Tables 4-1 and 4-3). The surface water sampling location is presented in Figure 4-3. Surface water sampling activities were recorded on a surface water sampling record and in a field logbook. The surface water sampling record is presented in Appendix C.

Surface water samples were collected using a decontaminated stainless steel ladle. Dedicated nitrile gloves were used to handle the ladle and sample containers, to minimize the potential for cross-contamination. Surface water samples were collected and preserved according to the specific requirements presented in Table 4-4. VOCs were collected first, followed by (in order) the volumes required for SVOCs, TPH, and TAL metals. Only total TAL metals were collected. Additional QA/QC volumes were collected as required per analysis. Split samples for the Vermont HMMD were collected per analysis.

Surface water samples submitted for laboratory analyses (including QA/QC samples) were labelled according to the method used for groundwater, presented in Section 4.3.4, except for location type, which was designated for surface water (SW) (e.g., V4-SW3-1094). Surface water samples were shipped for laboratory analyses according to the shipping and COC procedures presented in the SRI SAP (EARTH TECH 1994c).

Surface water sampling results, including laboratory analytical results, are discussed and presented in Section 5.0, Field Investigation Results. All surface water sample laboratory analytical data, and COC Forms, are presented in Appendix J.

4.3.6 Surface Sediment Sampling

Three surface sediment locations were sampled in the open drainage ditch of the eastern portion of Site 4 (V4-D1 through V4-D3) (Table 4-1). Three surface sediment samples (excluding QA/QC volumes) were submitted for laboratory analyses (Table 2-3). Surface sediment locations were labelled according to the following information: 1) base identifier - Vermont ANG Base (V) and IRP Site Number (3 or 4); 2) location type - surface sediment (D); and 3) location type sequential number (e.g., V4-D1). Surface sediment sample locations are presented in Figure 4-3.

Surface sediment samples were collected in 6-inch long, 1.5-inch OD stainless steel liners (the same as used for 2-inch OD split-spoon samplers). Samples were obtained by hand-pushing each liner from 0-0.5 foot bgs. Dedicated nitrile gloves were used to handle sample liners per location, in an effort to minimize the potential for cross-contamination. Prior to capping the liner a PID reading was taken and recorded. As with the split spoon samples, each sample liner was capped with Teflon® tape and covered with a tightly fitting polyethylene endcap. The first liner, selected for VOCs (highest PID reading, if applicable), was capped immediately

to prevent VOC loss. An additional liner sample was collected adjacent to the initial sample location for SVOCs, TPH, and TAL metals analyses. Additional liners for QA/QC samples and split samples for the Vermont HMMD were also collected adjacent to the original sample location. Surface sediment samples were collected per sample preservation requirements listed in Table 4-4 and shipped for laboratory analyses according to the shipping and COC procedures presented in the SRI SAP (EARTH TECH 1994c).

Sampling and lithologic data were recorded on surface sediment sampling records and in field logbooks. Lithologic descriptions of split-spoon samples and soil cuttings were logged according to the USCS, and Munsell® Color Chart colors for soil (Munsell® 1990) or rock (GSA 1991). Sediment sampling records are presented in Appendix C.

Surface sediment sampling results, including site geologic and laboratory analytical results, are discussed and presented in Section 5.0, Field Investigation Results. All surface sediment laboratory analytical data and COC forms are presented in Appendix J.

4.3.7 QA/QC Samples

Confirmation activity sample collection and laboratory analyses were conducted according to HAZWRAP QC Level C protocols (DOE/HWP-65RI 1990a, and DOE/HPW-69RI 1990b), as presented in the SRI SAP (EARTH TECH 1994c). HAZWRAP QC Level C protocols are designed to ensure technically defensible analytical data. These protocols include the collection and laboratory analyses of various QA/QC samples. QA/QC samples included trip blanks, field blanks, equipment rinseates, field duplicates, and MS/MSDs. Split samples are not included in HAZWRAP QC Level C QA/QC samples, but were collected during the ASI for the Vermont HMMD. Confirmation activity QA/QC sampling and analyses are summarized in Table 4-3.

QA/QC samples were collected and preserved according to the specific requirements presented in Table 4-4. QA/QC samples, other than field duplicates and matrix spike/matrix spike duplicates, submitted for laboratory analyses were labelled according to the following information: 1) QA/QC sample type - trip blank (TB), field blank (FB), or equipment rinseate (ER); 2) six digit date - day/month/year (101294); and 3) sequential sample type number per day, and/or for field blanks only, the field blank source - potable water (P) or DI water (D) (e.g., TB-102494-1, FB-102494-P, and ER-102894-1). Additional environmental sample volumes submitted for field duplicates and matrix spike/matrix spike duplicates were identified by adding additional qualifiers to environmental sample labels; field duplicate (-D) or matrix spike/matrix spike duplicate (-QA/QC). QA/QC samples were shipped for laboratory analyses according to the shipping and COC procedures presented in the SRI SAP (EARTH TECH 1994c).

QA/QC sample laboratory analytical data are discussed in Appendix H, Laboratory Analytical Data Quality, and in Appendix I, Data Validation Summaries. Some additional laboratory sample duplicates and matrix spikes/matrix spike duplicates were collected and analyzed by the laboratory for various analyses confirmation. All QA/QC sample laboratory analytical data and COC forms are presented in Appendix J. Laboratory analytical results for Vermont HMMD split samples are presented in Appendix E. ASI confirmation activity QA/QC samples are discussed in the following sections.

4.3.7.1 Trip Blanks

Trip blanks were provided by CompuChem Laboratory. Each trip blank consisted of two 40-ml glass vials completely filled with laboratory-grade water and preserved to a pH of less than 2 with hydrochloric acid (HCl). Trip blanks were prepared in the laboratory, shipped to the field with empty water sample containers, placed in each cooler used each day for any environmental media VOC sampling, returned to the laboratory with collected environmental samples, and analyzed for VOCs.

Trip blanks were utilized to evaluate potential cross-contamination of VOCs during environmental sample storage and shipping. Eleven trip blanks were submitted for VOCs analyses during the ASI.

4.3.7.2 Field Blanks

Field blanks were collected of all potable and DI water sources used for decontamination of drilling and sampling equipment. Field blanks were collected of each water source used per sampling event (or lot number for DI water) and submitted for environmental sample laboratory analyses (VOCs, SVOCs, TPH, and total TAL metals).

Field blanks were utilized to evaluate possible cross-contamination of environmental samples from potable and DI water sources. Potable water was obtained from base water system outlets. Field blanks of the potable water used for ASI activities were either collected directly from a base fire department outlet or from the drilling rig water tank and hose. Field blanks were collected according to the following frequencies: one potable water blank was collected per field shift, and one DI water blank was collected for each lot number used during the field program. One lot number of ASTM Type I DI water was used during the ASI. A total of four field blanks were collected and analyzed during the ASI; three potable water field blanks and one DI water field blank.

4.3.7.3 Equipment Rinseates

Equipment rinseates were collected from one lot number of ASTM Type I DI water poured over decontaminated sampling equipment (stainless steel sample liners, Teflon® bailers, and stainless steel ladle). Equipment rinseates were collected for laboratory analyses (VOCs, SVOCs, TPH, and total TAL metals).

Equipment rinseates served to characterize the effectiveness of sample equipment decontamination procedures. Equipment rinseates were collected for each sample media at a frequency of 1 for every 10 environmental samples collected per field shift. Seven equipment rinseates were collected and analyzed during the ASI. Five equipment rinseates were collected for thirty soil samples and three surface sediment samples from five decontaminated stainless steel sample liners. One equipment rinseate was collected for six groundwater samples from one decontaminated Teflon® bailer. One equipment rinseate was collected for one surface water sample from one decontaminated stainless steel ladle.

4.3.7.4 Field Duplicates

Soil and surface sediment field duplicates were collected in the field and in the laboratory from soil and surface sediment sample liners, as discussed in Sections 4.3.1 and 4.3.6, respectively. Groundwater and surface water duplicates were collected in field and submitted to the laboratory in separate containers, as discussed in Sections 4.3.4 and 4.3.5, respectively. Field duplicates were collected and analyzed for environmental sample laboratory analyses [VOCs, SVOCs, TPH, and total and dissolved (groundwater only) TAL metals].

Field duplicates were used for laboratory analytical confirmation and were collected for each sample media at a frequency of 1 for every 10 environmental samples collected per field shift. Six field duplicates were collected and analyzed during the ASI. Four field duplicates were collected for thirty soil samples. One field duplicate was collected for each of the following: six groundwater samples, one surface water sample, and one surface sediment sample.

4.3.7.5 Matrix Spikes and Matrix Spike Duplicates

Soil and surface sediment MS/MSDs were collected in the field and in the laboratory from soil and surface sediment sample liners, as discussed in Sections 4.3.1 and 4.3.6, respectively. Groundwater and surface water MS/MSDs were collected in field and submitted to the laboratory in separate containers, as discussed in Sections 4.3.4 and 4.3.5, respectively. MS/MSDs were collected for environmental sample laboratory analyses (VOCs, SVOCs, TPH, and total TAL metals).

MS/MSDs were used for laboratory analytical confirmation and were collected for each sample media at a frequency of 1 for every 20 environmental samples collected per field shift. Seven MS/MSDs were collected and analyzed during the ASI. Four MS/MSDs were collected for thirty soil samples. One MS/MSD was collected for each of the following: six groundwater samples, one surface water sample, and one surface sediment sample.

4.3.7.6 Split Samples

Soil and surface sediment split samples were collected in the field and in the laboratory from soil and surface sediment sample liners, as discussed in Sections 4.3.1 and 4.3.6, respectively. Groundwater and surface water split samples were collected in the field and submitted to the laboratory in separate containers, as discussed in Sections 4.3.4 and 4.3.5, respectively. Split samples were collected for Vermont HMMD selected analyses [VOCs, SVOCs, pesticides/polychlorinated biphenyls (PCBs), and total and dissolved (groundwater only) TAL metals]. Sampling and analysis for PCBs was not included in the ASI, based on the suspected contaminants presented by the Vermont ANG Base.

Split samples were collected for the Vermont HMMD for comparative analyses in a separate laboratory contracted to the Vermont HMMD. Split samples were generally collected for each sample media at a frequency of 1 for every 15 environmental samples collected. Five split samples were collected and submitted to the Vermont HMMD for analyses during the ASI. Two split samples were collected for thirty soil samples. One split sample was collected for each of the following: six groundwater samples, one surface water sample, and one surface sediment sample.

4.3.8 Laboratory Analytical Methods

Laboratory analyses were conducted according to HAZWRAP QC Level C specifications (DOE/HWP-65/RI 1990a), as stated in the SRI SAP (EARTH TECH 1994c). Laboratory analytical methods for soil and water environmental and QA/QC samples are summarized in Table 4-3. Sample collection and preservation requirements are presented in Table 4-4.

Laboratory analysis of confirmation activity soil and water samples included the following: VOCs according to EPA SW-846 Methods 8010/8020 (chlorinated/non-chlorinated); SVOCs according to EPA Contract Laboratory Program (CLP) Methods, March 1990 (3/90) Revision for soils and October 1992 (10/92) Revision for waters; TPH according to California Modified Method 8015; and TAL metals according to EPA CLP Methods, 3/90 Revision for both soils and waters. EPA SW-846 refers to "Test Method for Evaluating Solid Waste - Physical/Chemical Methods," EPA SW-846, 3rd Edition, November 1986 (EPA 1986). EPA CLP refers to "EPA CLP, Statement of Work for Organics Analyses, Multi-Media, Multi-Concentration," 3/90 and 10/92 Revisions (EPA 1990a and EPA 1992), and "EPA CLP, Statement of Work for Inorganics Analyses, Multi-Media, Multi-Concentration," 3/90 Revision (EPA 1990b). California Modified Method 8015 refers to "Leaking Underground Fuel Tank (LUFT) Field Manual," State Water Resources Control Board, State of California, May 1988 (California 1988).

Vermont HMMD laboratory analyses for split samples included EPA SW-846 Methods (EPA 1986); Method 8240 for VOCs, Method 8270 for SVOCs, Method 8080 for pesticides/PCBs, and 6000/7000 Series Methods for TAL metals. Vermont HMMD laboratory analytical results for split samples and COC forms are presented in Appendix E.

ASI laboratory analytical data quality is discussed in Appendix H, and an ASI data validation summaries are presented in Appendix I. Laboratory analytical results are discussed and presented in Sections 5.0, Field Investigation Results. All laboratory analytical data and COC forms are presented in Appendix J.

4.3.9 Boring Abandonment

Soil borings were abandoned by filling each remaining borehole volume with cement-bentonite grout as presented in the ASI SAP (EARTH TECH 1994c) and approved by the Vermont HMMD. Cement-bentonite grout consisted of Iron Clad® Portland Type I cement mixed with Wyo-Ben® granular bentonite and potable water. The grout mix ratio was generally 94 lbs of cement with 5 to 6 lbs of granular bentonite and 6-8 gallons of potable water. Grout mixtures were pressure-tremied from total depth to the surface. Soil boring abandonment activities were recorded in field logbooks.

4.3.10 Decontamination

Major equipment (i.e., drilling rig, hollow-stem augers, sample rods, etc.) were decontaminated prior to beginning work at the facility. Subsequent decontamination (decon) of all downhole equipment (augers, sample rods, etc.) was conducted between boring locations. Subsequent decontamination of the back of the drilling rig was conducted between sites, and generally once a day. Decon consisted of steam cleaning the equipment with pressurized hot water (in

the vicinity of 180°F). Decon activities and equipment staging were conducted in a designated area, located in IRP Site 1, in the northeast portion of the base. Drilling equipment decon was conducted over a temporary holding pad built to contain all decon-derived waters and sediments. Contained wastewater (and suspended sediment) was routinely pumped to large volume polyethylene tanks, located adjacent to the decon pad.

Sampling equipment, which directly contacted soil and water environmental samples, such as split-spoon samplers, stainless steel sample liners, stainless steel knives, stainless steel and Teflon® bailers and attachments, and a stainless steel ladle, was decontaminated between samples as follows:

- Scrubbed and washed with potable water and laboratory grade detergent (Liqu-nox®);
- Rinsed with potable water;
- Rinsed with ASTM Type I DI water;
- Rinsed with pesticide-grade methanol;
- Air dried;
- Wrapped in aluminum foil (if not used immediately).

Water level meters and oil/water probes were decontaminated between locations by rinsing the lead probe and adjacent length of tape with ASTM Type I DI water. A full decon was implemented if the equipment encountered free-product or exhibited a hydrocarbon odor upon retrieval from the well casing. All wastewaters generated during the decontamination procedures were containerized in large volume polyethylene tanks staged at IRP Site 1, and subsequently characterized and disposed of as described in Section 4.3.11.

4.3.11 Waste Handling

All laboratory analytical results for wastewaters and soil cuttings are presented in Appendix F. Based on laboratory analytical results, all investigation derived wastes (IDW) were disposed of on-site. Soil cuttings were dispersed at each boring or well location and wastewaters were discharged to the local sanitary sewer system.

Miscellaneous IDW, such as used polypropylene tubing, plastic sheeting, empty sample containers, latex or nitrile gloves, Tyvek® coveralls, paper towels, aluminum foil, etc., were not considered hazardous and were disposed of on-site in base trash dumpsters. Detailed waste handling and characterization procedures are presented in the following discussions for wastewaters and soil cuttings.

4.3.11.1 Wastewaters

Wastewaters from all ASI and SRI activities were stored in three polyethylene tanks (1500, 1300, and 1050 gallon tanks) located in the staging area at IRP Site 1. Samples were collected from each tank and submitted for laboratory analyses for VOCs only, as opposed to

the full suite of water analyses presented in the SRI SAP (EARTH TECH 1994c). The change in wastewater sampling and analyses, approved by the Vermont HMMD and the Vermont Wastewater Management Division (WMD), was effected to enable faster turnaround on analytical results and subsequent disposal. The change in procedure is documented in FCR Number 1, presented in Appendix A. According to the modified procedure, each tank was sampled for VOCs according to EPA SW-846 Methods 8010/8020 (EPA 1986). Samples were collected and preserved according to the requirements presented in Table 4-4, and stored and shipped for laboratory analyses according to the procedures stated in the SRI SAP (EARTH TECH 1994c). If laboratory analytical results indicated any VOC concentration in excess of 100 times respective State of Vermont Primary Groundwater Quality Enforcement Standards (Vermont 1988), additional sampling and laboratory analyses would be required (SVOCs, pesticides/PCBs, TPH, and TAL metals), otherwise the wastewater could be disposed of in the base sanitary sewer system, which transmits wastewater to the City of South Burlington - Airport Road Wastewater Treatment Facility. State of Vermont ARARs are presented in Appendix G. Laboratory analytical results for the three tanks indicated no significant concentrations of VOCs. Analytical results were provided to the Vermont HMMD and WMD, and to the City of South Burlington Water Pollution Control Department - Airport Road Wastewater Treatment Facility. Contained ASI/SRI wastewaters were discharged to the base sanitary sewer system in October 1994 and June 1995. Laboratory analytical results for VOCs in wastewaters [polyethylene tank samples PT10 (1050-gallon tank, October 1994), PT13 (1300-gallon tank, October 1994), and PT15 (1500-gallon tank, October 1994 and June 1995)] are presented in Appendix F.

4.3.11.2 Soil Cuttings

All soil cuttings were covered in plastic sheeting and staged at each boring location, until laboratory analytical results on subsurface soil and/or groundwater samples were available. Soil cuttings from borings exhibiting elevated concentrations of organics in soil and/or groundwater samples, in excess of State of Vermont ARARs (Table 4-5), were composited and sampled for applicable EPA SW-846 Toxicity Characteristic Leaching Procedure (TCLP) analyses (EPA 1986). State of Vermont ARARs are presented in Appendix G. Detections of organic compounds in soil samples were compared to 1992 State of Vermont Residual Soil Values (Vermont 1992a). Laboratory detections of inorganics in soil and groundwater samples were not included in the evaluation of soil cuttings, as approved by the Vermont HMMD (Telecon 1995b). State of Vermont Residual Soil Values are equal to 20 times respective Primary Groundwater Quality Enforcement Standards (if available), to account for the dilution factor attributable to the leaching of organic contaminants from soil to groundwater. Four locations in Site 3 (V3-BG1, V3-B1, V3-B2, and V3-MW3) and four locations in Site 4 (V4-BG1, V4-B2, V4-B3, V4-B6, and V4-MW3) exhibited no detections of organics in soil and/or groundwater samples equal to or in excess of State of Vermont ARARs. In May 1995, soil cuttings from these locations (except for V3-B1, based on a Vermont HMMD request) were subsequently dispersed around each boring location, and the discarded staging plastic was disposed of as general trash. Five locations in Site 3 (V3-B3, V3-B4, V3-B5, V3-MW1, and V3-MW2) and four locations in Site 4 (V4-B1, V4-B4/MW2, V4-B5, and V4-MW1) exhibited detections of organic compounds in soil and/or groundwater samples equal to or in excess of State of Vermont ARARs. In May 1995, one soil sample was collected from soil cuttings from each of these locations and composited per site (including V3-B1 at Site 3), using decontaminated stainless steel sample liners and stainless steel mixing bowls. Each

**Table 4-5 Boring/Monitoring Well Locations Exhibiting Organic Contaminant
Concentrations in Excess of Vermont ARARs
Abbreviated Site Investigation - Installation Restoration Program Sites 3 and 4
Vermont Air National Guard Base**

Site 3	Site 4
V3-B1	V4-B1
V3-B3	V4-B4 (V4-MW2)
V3-B4	V4-B5
V3-B5	*V4-MW1
V3-MW1	
*V3-MW2	

Additional characterization of soil cuttings was conducted at each boring/monitoring well location, and consisted of the collection of one composite soil cuttings sample per site, and submittal to an off-site laboratory for Toxicity Characteristic Leaching Procedure (TCLP) analysis for Volatile Organic Compounds (VOCs).

* Based on the presence of free-product in the monitoring well.

composite sample was collected in (1) 4-oz. glass jar, and shipped to the laboratory for TCLP extract analyses for a full suite of EPA SW-846 Method 8240 VOCs. VOCs of concern, in excess of Vermont ARARs, included: benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, styrene, toluene, and total xylenes. Samples were stored and shipped according to the procedures stated in the SRI SAP (EARTH TECH 1994c). TCLP analytical results for VOCs were characterized according to EPA toxicity characteristic (TC) standards (EPA 1991). No TCLP detections were indicated, other than minor detections of acetone and methylene chloride; therefore, no soil cuttings were characterized as hazardous and required further action. Base personnel may subsequently disperse the remaining cuttings at each borehole and dispose of discarded plastic sheeting as general trash. TCLP analytical results for VOCs in composite soil cuttings samples from Site 3 (composite sample V3-TCLP) and from Site 4 (composite sample V4-TCLP) are presented in Appendix F.

4.3.12 Surveying

Site surveying was conducted by a state licensed surveyor in October 1994; Pinkham Engineering Associates, Incorporated of Burlington, Vermont. Planar coordinates for the state of Vermont are currently non-existent; therefore, survey coordinates (horizontal and vertical) were tied into local pre-existing bench marks developed for Vermont ANG Base and adjoining Burlington International Airport. Horizontal coordinates were tied to North American Datum (NAD) 27, to a third order accuracy. Vertical coordinates were tied to National Geodetic Vertical Datum 29. The measured horizontal survey traverse was adjusted to an accuracy of 1:50,000 (1 foot of closure error for every 50,000 ft of survey traverse), and were of third order accuracy. Vertical measurements, or elevations in ft AMSL, were determined to an accuracy of 0.01-foot.

Horizontal coordinates and ground surface elevations were determined for all confirmation activity soil borings, monitoring wells, and surface sediment and water sample locations. Selected field screening locations were also surveyed in at each site for additional reference data. Top of casing (TOC) elevation was also determined for all monitoring wells. The top of each monitoring well casing (TOC) was notched to provide a reference point for the land surveyors and for subsequent water level and free-product elevation measurements. All site survey results are provided in Appendix D.

5.0 FIELD INVESTIGATION RESULTS

The results of the 1994-1995 ASI field program conducted at IRP Sites 3 and 4 at Vermont ANG Base are discussed in the following sections. ASI field screening and confirmation activities are presented in detail in Section 4.0, Field Program Summary, and summarized in Tables 4-1 through 4-3. The ASI program consisted of field screening activities: SOV surveys, groundwater screening, and installation of temporary piezometers, and confirmation activities: soil boring and subsurface soil sampling, groundwater monitoring well installation and development, groundwater sampling, surface water and sediment sampling, water level and free-product measurements, and off-site laboratory analysis of environmental samples for VOCs, SVOCs, TPH, and TAL metals.

Section 5.1 presents the geology/hydrogeology of Sites 3 and 4. Section 5.2 presents ASI analytical results for IRP Sites 3 and 4; field screening and laboratory analytical results. Section 5.3 presents a brief contamination summary per site.

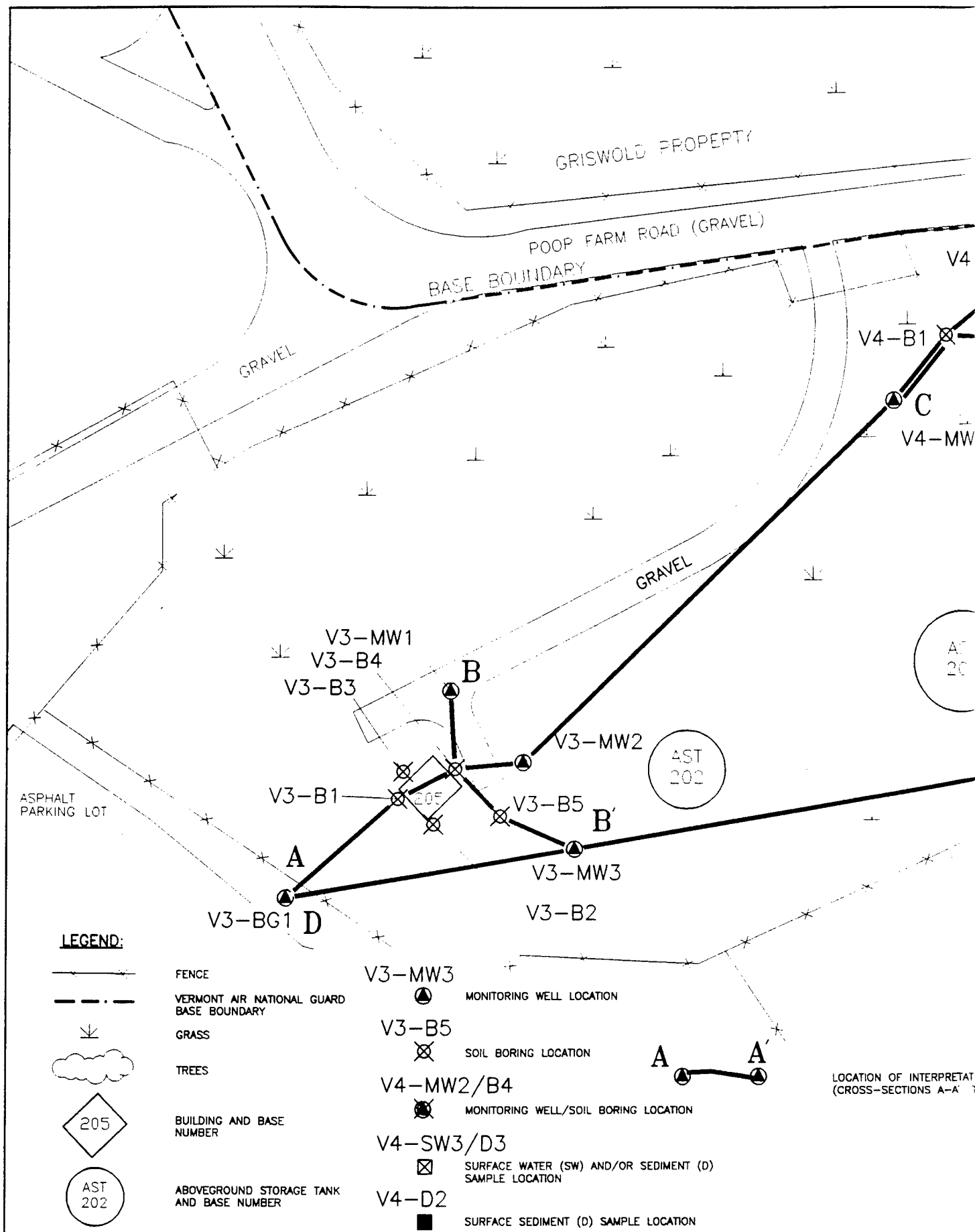
5.1 GEOLOGY/HYDROGEOLOGY

Local geologic and hydrogeologic settings for Sites 3 and 4 are presented in the following sections.

5.1.1 Site Geology

The regional and local geologic setting of Vermont ANG Base was discussed in Section 3.4 of this report. The following interpretation of site geology is based on data generated from confirmation drilling and soil sampling activities in Sites 3 and 4. Geologic interpretations are based on boring logs, consisting of lithologic data derived from examination of hollow-stem auger cuttings, drilling rates, and split-spoon soil samples. Nineteen boring logs were generated from 11 soil borings, 6 monitoring wells, and 2 background soil borings/monitoring wells. Boring log data extends from the surface to 70 ft bgs in Site 3, and from the surface to 95 ft bgs in Site 4. Figure 5-1 presents the location of the soil borings and monitoring wells in Sites 3 and 4, and the locations of interpretative geologic cross-sections A-A', B-B', C-C', and D-D' (Figures 5-2 through 5-5). Lithologic interpretations are presented in the following discussion. Lithologies are identified according to the USCS. Boring logs and monitoring well construction logs are presented in Appendix C.

Generally, Quaternary-age silts and sands with trace to minor occurrences of gravel and clay underlie Sites 3 and 4. This lithologic unit is termed upper overburden in this report. No bedrock or hollow-stem auger refusal was encountered at either site. Attempts were made to drill and sample to the local bedrock surface in boring V3-BG1 (TD 70 ft) in Site 3, and in borings V4-BG1 (TD 95 ft) and V4MW3 (TD 53 ft) in Site 4. Drilling and sampling below the water table, using the hollow-stem auger methods, was generally hindered by the presence of heaving sands and silts. Split-spoon sampling below the water table in boring V4-BG1 was especially hindered by heaving sand and silt; therefore, an attempt was made to identify zones of dense sediments or auger refusal by changes in the drilling rate; no changes were noted.



GRISWOLD PROPERTY

R FARM ROAD (GRAVEL)
RY

DITCH

V4-SW3/D3

V4-MW2/B4

V4-B5

V4-B2

V4-B3

V4-B6

V4-B1

V4-MW1

230

GRAVEL

AST
203

AST
PARK

3-MW2

35
B'

-MW3

-B2

V4-BG1

LOCATION

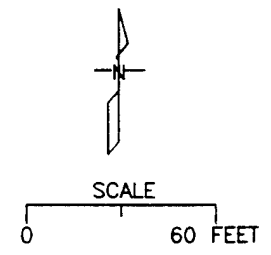
STION

'SOIL BORING LOCATION

SW) AND/OR SEDIMENT (D)

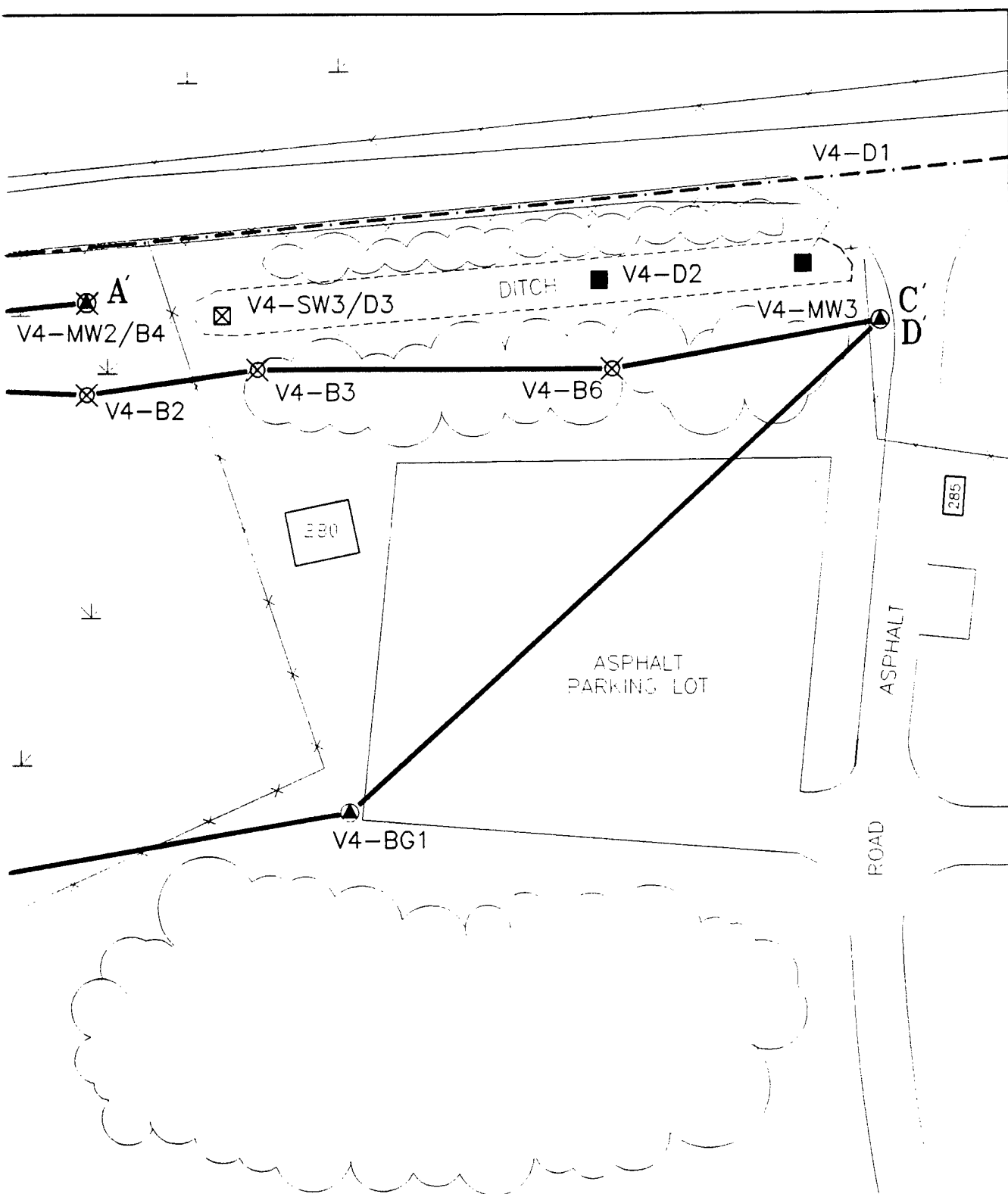
T (D) SAMPLE LOCATION

LOCATION OF INTERPRETATIVE GEOLOGIC CROSS-SECTION
(CROSS-SECTIONS A-A' THROUGH D-D')



EARTH

SITE
MONITORIN
SEDIMI
P
C



CROSS-SECTION



SCALE

0 60 FEET

EARTH TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
SOUTH BURLINGTON, VERMONT

SITES 3 AND 4 - SOIL BORING,
MONITORING WELL, AND SURFACE WATER AND
SEDIMENT SAMPLING LOCATIONS, WITH
INTERPRETATIVE GEOLOGIC
CROSS-SECTION LOCATIONS

FIGURE 5-1

FEET
ABOVE
MEAN
SEA
LEVEL

A
SOUTHWEST
0

70

102

139

FEET

330
320
310
300
290
280
270
260
250

V3-BG1
325.90

V3-B1
297.60'

V3-B4
297.54'

V3-MW2
297.97'

205

TD-15'

TD-15'

TD-26'

TD-70'

VERTICLE EXAGGERATION: 3 X HORIZONTAL

SCALE 0 60
FEET

LEGEND



SILTY SAND (SM to ML)



FINE GRAINED TO MEDIUM GRAINED
SAND W/ GRAVEL (SP to SW)



CLAYEY SILT TO SILTY CLAY
(ML to CL)

CONTACTS DASHED WHERE INFERRED
UNIFIED SOIL CLASSIFICATION SYSTEM
(USCS) DESIGNATIONS IN PARENTHESIS



MEASURED OCTOBER 1994 WATER
LEVEL ELEVATION



APPARENT OCTOBER 1994 WATER TABLE
(DASHED WHERE INFERRED)



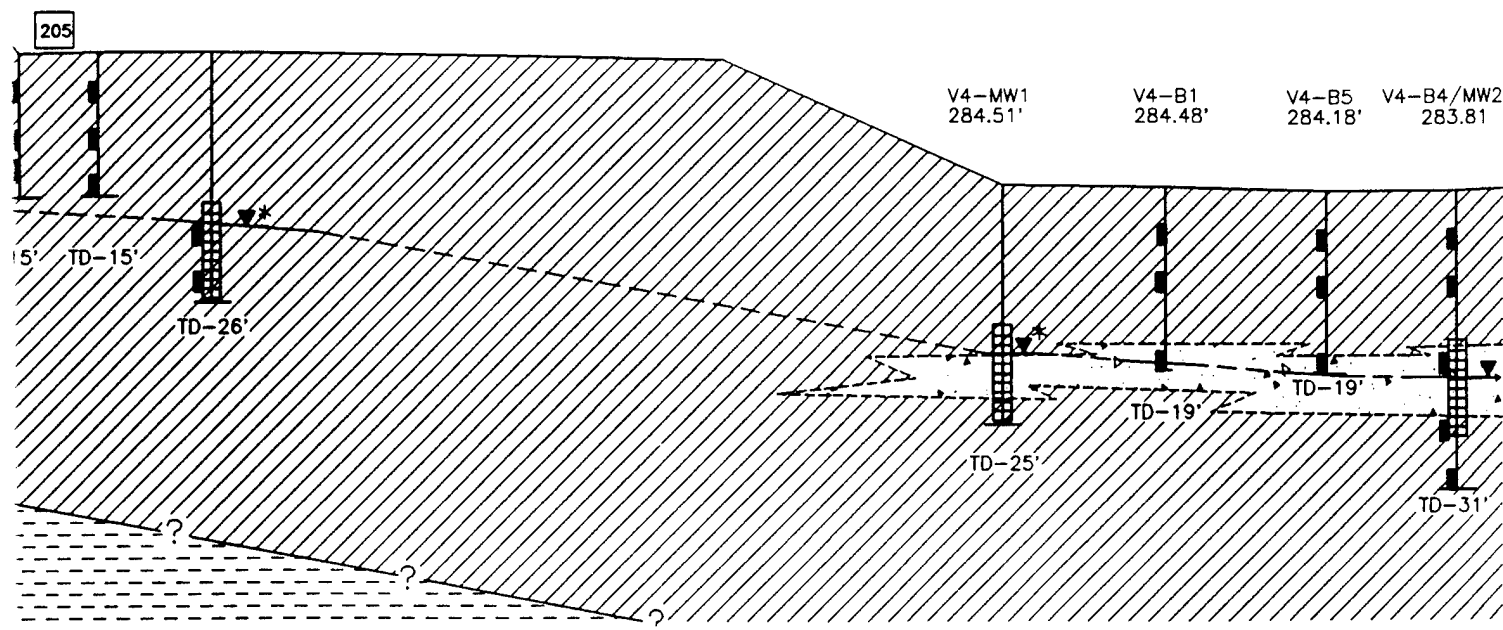
* DENOTES THE PRESENCE OF
FREE PRODUCT

205

APPROXIMATE LOCATION OF
BUILDING 205



-B1 7.60' V3-B4 297.54' V3-MW2 297.97'

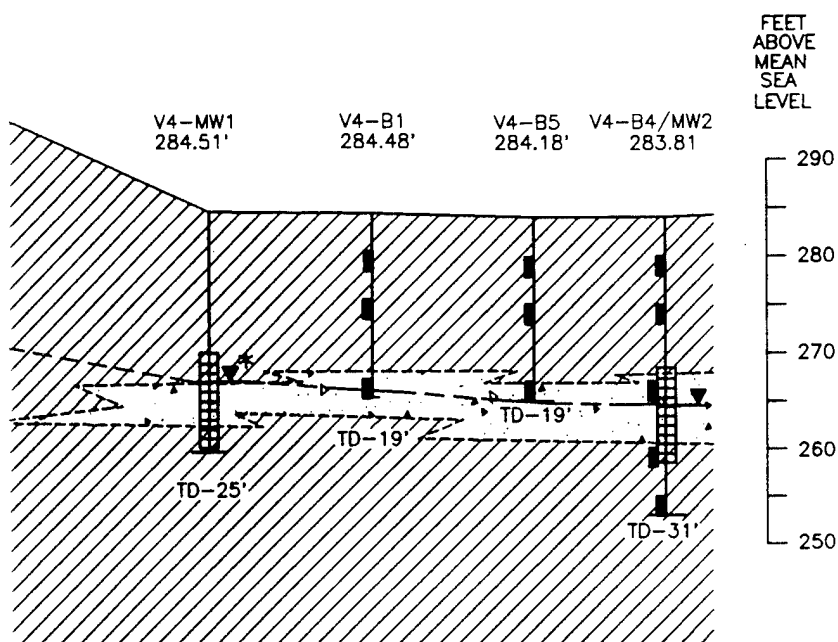
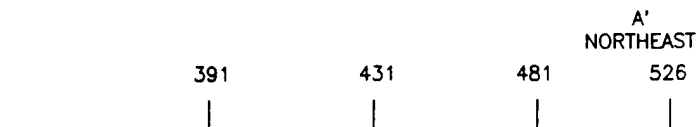


ITAL

- MEASURED OCTOBER 1994 WATER LEVEL ELEVATION
- APPARENT OCTOBER 1994 WATER TABLE (DASHED WHERE INFERRED)
- DENOTES THE PRESENCE OF FREE PRODUCT
- APPROXIMATE LOCATION OF BUILDING 205

- V4-B-1 284.48' BORING IDENTIFICATION
- GROUND ELEVATION IN FEET ABOVE MEAN SEA LEVEL
- SPLIT-SPOON SAMPLE LOCATION
- 0.01-INCH SLOT PVC SCREEN
- TD-26' TOTAL DEPTH IN FEET

EARTH
SITE



-B-1 BORING IDENTIFICATION
 4.48' GROUND ELEVATION
 IN FEET ABOVE
 MEAN SEA LEVEL

SPLIT-SPOON SAMPLE
 LOCATION

0.01-INCH SLOT
 PVC SCREEN

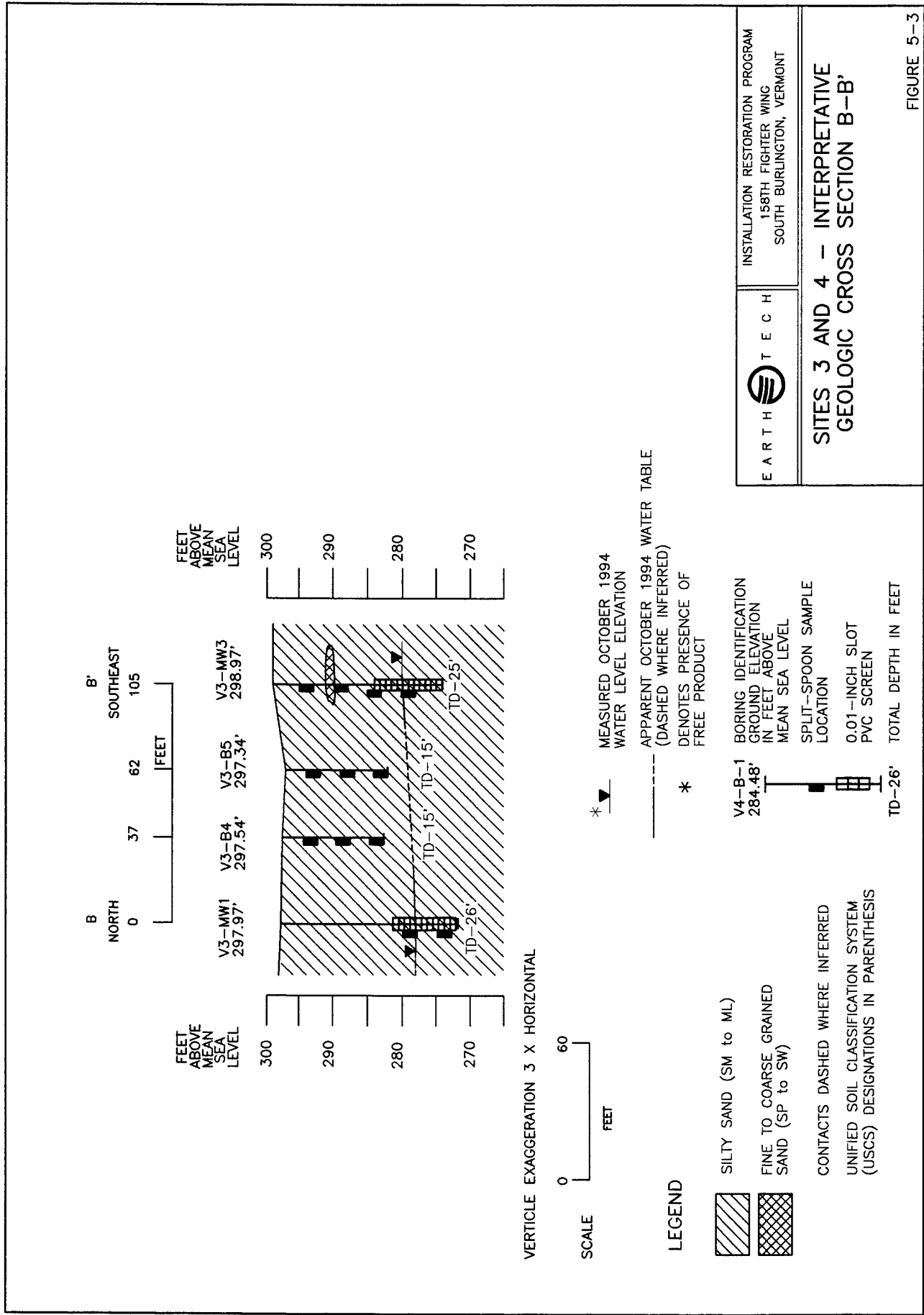
-26' TOTAL DEPTH IN FEET

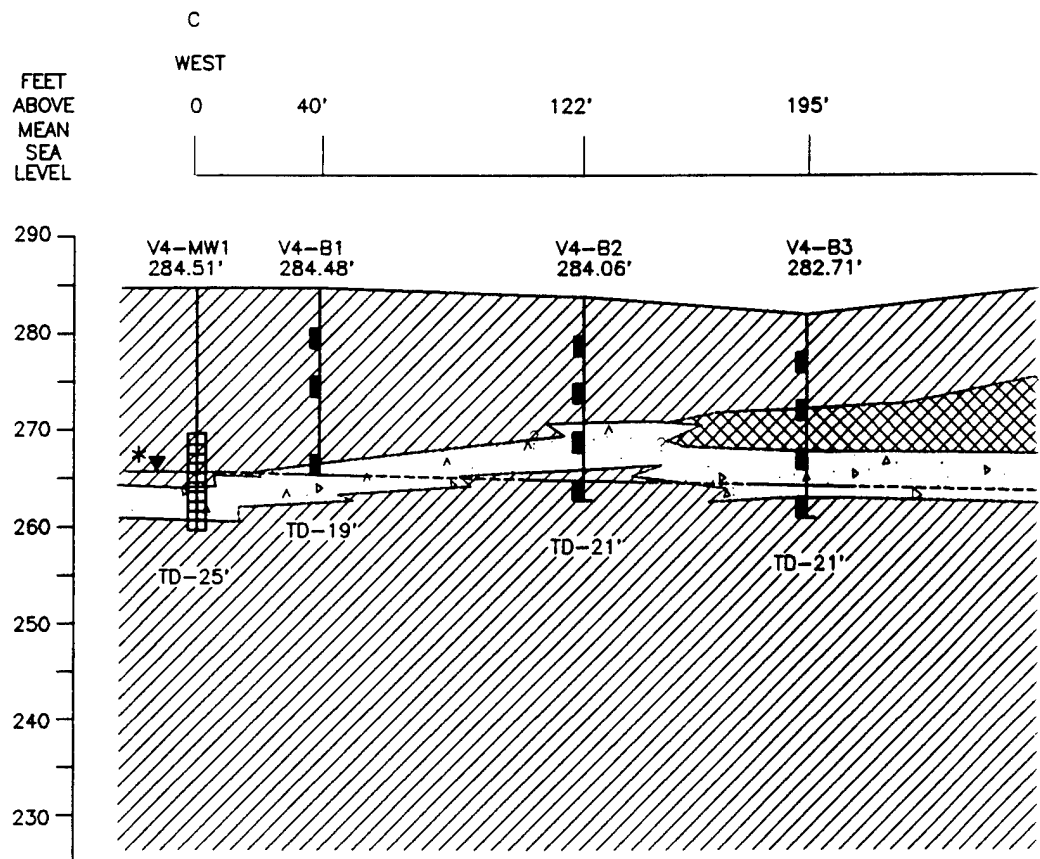
EARTH  TECH

INSTALLATION RESTORATION PROGRAM
 158TH FIGHTER WING
 SOUTH BURLINGTON, VERMONT

SITE 3 & 4 - INTERPRETATIVE GEOLOGIC
 CROSS SECTION A-A'

FIGURE 5-2








VERTICLE EXAGGERATION: 3 X HORIZONTAL

SCALE 0 60
FEET

LEGEND

-  SILTY SAND (SM to ML)
-  FINE TO COARSE GRAINED SAND (SP to SW)
-  FINE TO MEDIUM GRAINED SAND W/
MINOR GRAVEL (SP to SW)

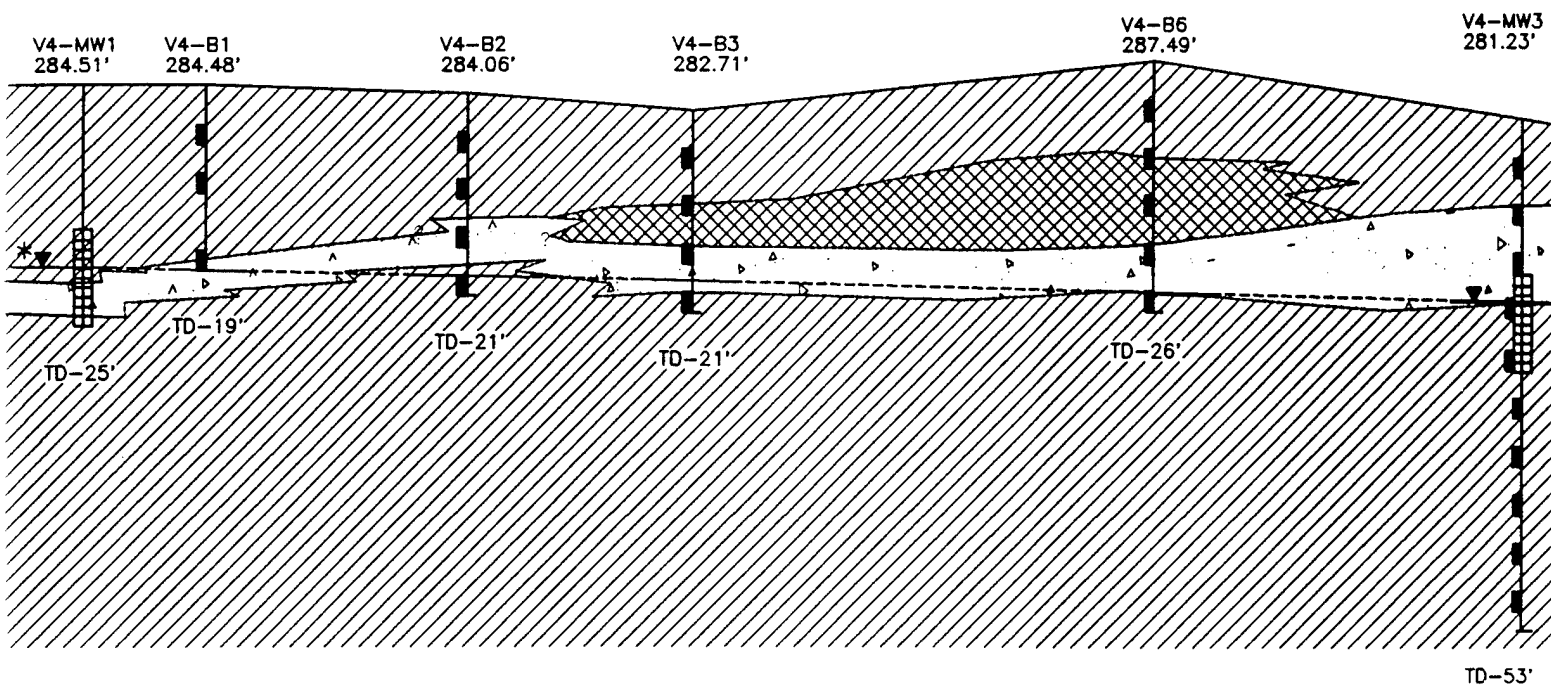
CONTACTS DASHED WHERE
INFERRED

UNIFIED SOIL CLASSIFICATION (USCS)
DESIGNATIONS IN PARENTHESIS

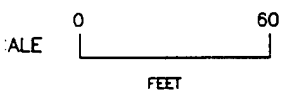
*  MEASURED OCTOBER 1994 V
LEVEL ELEVATION

--- APPARENT OCTOBER 1994 W
(DASHED WHERE INFERRED)

* DENOTES PRESENCE OF
FREE PRODUCT



TITLE EXAGGERATION: 3 X HORIZONTAL



SILTY SAND (SM to ML)

FINE TO COARSE GRAINED SAND (SP to SW)

FINE TO MEDIUM GRAINED SAND W/
MINOR GRAVEL (SP to SW)

CONTACTS DASHED WHERE
INFERRED

UNIFIED SOIL CLASSIFICATION (USCS)
DESIGNATIONS IN PARENTHESIS



MEASURED OCTOBER 1994 WATER
LEVEL ELEVATION



APPARENT OCTOBER 1994 WATER TABLE
(DASHED WHERE INFERRED)

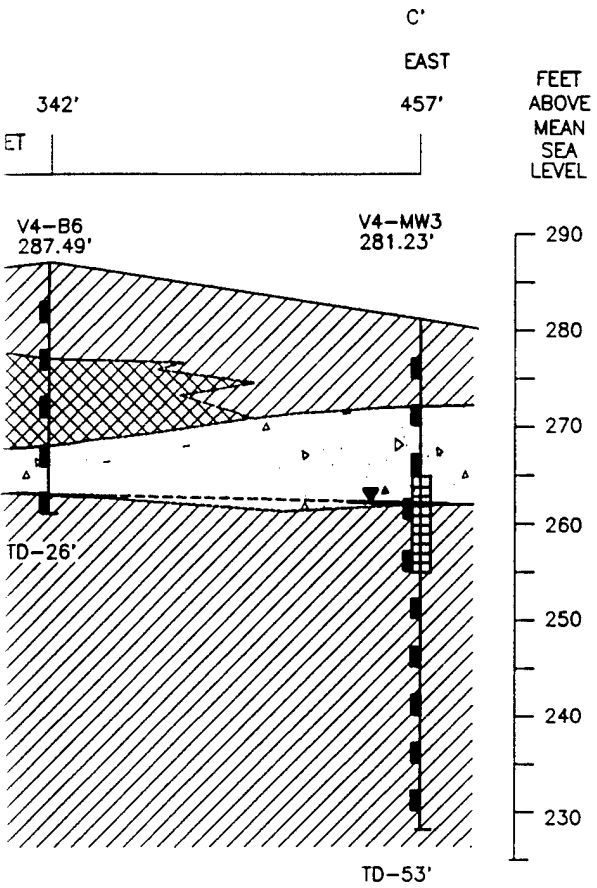
* DENOTES PRESENCE OF
FREE PRODUCT

V4-B-1 284.48' BORING IDENTIFICATION
GROUND ELEVATION
IN FEET ABOVE
MEAN SEA LEVEL

SPLIT-SPOON SAMPLE
LOCATION

0.01-INCH SLOT
PVC SCREEN

TD-19' TOTAL DEPTH IN FEET



V4-B-1 BORING IDENTIFICATION
284.48' GROUND ELEVATION
IN FEET ABOVE
MEAN SEA LEVEL

SPLIT-SPOON SAMPLE
LOCATION

0.01-INCH SLOT
PVC SCREEN

TD-19' TOTAL DEPTH IN FEET


	INSTALLATION RESTORATION PROGRAM 158TH FIGHTER WING SOUTH BURLINGTON, VERMONT
	<p>SITES 3 AND 4 - INTERPRETATIVE GEOLOGIC CROSS SECTION C-C'</p>

FIGURE 5-4

FEET

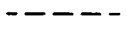
516

V4-BG1
288.31

60



MEASURED OCTOBER 1994 WATER
LEVEL ELEVATION



APPARENT OCTOBER 1994 WATER TABLE
(DASHED WHERE INFERRED)

V4-B1
284.48'

BORING IDENTIFICATION
GROUND ELEVATION
IN FEET ABOVE
MEAN SEA LEVEL



SPLIT-SPOON SAMPLE
LOCATION



0.01-INCH SLOT
PVC SCREEN

TD-26'

TOTAL DEPTH IN FEET

TD-95'

EARTH

SITE 3 &

516

D' NORTHEAST
816 FEET ABOVE
MEAN
SEA LEVEL

V4-BG1
288.31

V4-MW3
281.23'

TD-53'

TD-95'

330
320
310
300
290
280
270
260
250
240
230
220
210
200
190

EARTH  TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
SOUTH BURLINGTON, VERMONT

SITE 3 & 4 - INTERPRETATIVE GEOLOGIC
CROSS SECTION D-D'

FIGURE 5-5

3

5-6

In the following discussion of site lithologies, USCS designations are presented in parentheses. Across Sites 3 and 4, subsurface soils (sediments) dominantly consist of brown to yellowish-brown to olive gray, very fine to medium grained, silty sand and sandy silt (SM to ML). Generally thin deposits (approximately 1 to 10 ft in thickness) of olive gray to light olive gray and gray to yellowish-brown, fine to coarse grained sand, with or without minor gravel, occur locally (SP to SW), primarily across most of Site 4. The sand (SP to SW) lithologies occurred at depths ranging from 9 to 24 ft bgs and were not encountered south and southwest of Site 4. Gray, sandy silt and clayey silt (ML) were encountered in background soil boring V4-BG1 from approximately 60 ft to total depth at 95 ft bgs. Dark gray, silty clay (CL) was encountered at total depth (approximately 70 ft bgs) in background boring V3-BG1. The silt and clay lithologies (ML to CL) may occur at depths in excess of 50 ft bgs across Sites 3 and 4; however, correlation data are limited. Locally, some surface to shallow subsurface sediments (estimated from the surface to 5 to 10 ft bgs) present in Sites 3 and 4, have probably been reworked during previous POL facility or subsurface utility construction. Differentiation of fill or reworked sediments versus undisturbed sediments was not apparent during this investigation.

Interpretative geologic cross-sections A-A', B-B', C-C', and D-D' were presented in Figures 5-2 through 5-5, respectively. Cross-section locations were selected to illustrate the vertical and horizontal extent of geologic lithologies across Sites 3 and 4. Most ASI soil borings and monitoring wells are represented. Geologic interpretation is focused on differentiation of sand, silt, gravel, and clay lithologies. Most depths and thicknesses of lithologic units are approximated, based on available data. Split-spoon sample locations and water table elevation data from October 21-22, 1994 are also presented on each profile. Split-spoon locations illustrated per boring represent attempted sample intervals and do not reflect actual spoon recovery.

Geologic cross-section A-A' (Figure 5-2) presents a southwest to northeast profile of Sites 3 and 4. Quaternary-age subsurface sediments, as previously described, were encountered in all borings presented. Boring TDs range from 70 ft in V3-BG1 to 15 ft bgs in V3-B1 and V3-B4. Silty sand or sandy silt (SM to ML) is the dominant lithology, present from the surface to TD in all borings presented. A subsurface lens (approximately 4 to 7 ft in thickness) of sand with minor silt or gravel (SP to SW) was encountered at depths ranging from approximately 17 to 24 ft bgs in all Site 4 borings illustrated. Silty clay (CL) was encountered at total depth in boring V3-BG1. The thickness and areal extent of this lithology is not defined, but is inferred at depth across Sites 3 and 4. Water level data indicate a northward-northeastward sloping water table, occurring from 41.85 ft bgs in well V3-BG1 to 17.76 ft bgs in well V3-MW2. The presence of free-product (measured October 22, 1994) is noted in Site 3 well V3-MW3 and in Site 4 well V4-MW1.

Geologic cross-section B-B' (Figure 5-3) presents a northwest to southeast profile of Site 3. Quaternary-age subsurface sediments, as previously described, were encountered in all borings presented. Boring TDs range from 26 ft in V3-MW1 to 15 ft bgs in V3-B4 and V3-B5. Silty sand or sandy silt (SM to ML) is the dominant lithology, present from the surface to TD in all borings presented. A thin lens of fine to coarse grained sand (SW) was encountered from approximately 9 to 9.7 ft bgs in boring V3-MW3. Water level data indicate a slightly northward-northeastward sloping water table, occurring from 19.05 ft bgs in well V3-MW1 to 18.65 ft bgs in well V3-MW3.

Geologic cross-section C-C' (Figure 5-4) presents a west to east profile of Site 4. Quaternary-age subsurface sediments, as previously described, were encountered in all borings presented. Boring TDs range from 53 ft in V3-MW3 to 19 ft bgs in V4-B1. Silty sand or sandy silt (SM to ML) is the dominant lithology, present from the surface to TD in all borings presented. A subsurface lens (approximately 4 to 10 ft in thickness) of sand and/or sand with minor silt or gravel (SP to SW) was encountered in all borings from depths ranging from 9 to 24 ft bgs. The thickest lens deposit (approximately 15 ft in thickness) was encountered in Site 4 boring V4-B6. Water level data indicate a northward-northeastward sloping water table, occurring from 19.85 ft bgs in well V4-MW3 to 18.89 ft bgs in well V4-MW1.

Geologic cross-section D-D' (Figure 5-5) presents a southwest to northeast profile of Sites 3 and 4. Quaternary-age subsurface sediments, as previously described, were encountered in all borings presented. Boring TDs range from 95 ft in V4-BG1 to 21 ft bgs in V3-MW3. Silty sand or sandy silt (SM to ML) is the dominant lithology, present from the surface to TD in all borings presented. Subsurface lenses (approximately less than 1 ft to 10 ft in thickness) of sand and sand with minor silt or gravel (SP to SW) were encountered in Site 3 boring V3-MW3 and in both Site 4 borings (V4-BG1 and V4-MW3). Clayey silt and silty clay (ML to CL) deposits were encountered at depths ranging from approximately 60 to 70 ft bgs in borings V3-BG1 and V4-BG1. The vertical and horizontal extent of these silt and clay deposits is not defined, but is inferred at depth on cross-sections A-A' and D-D'. Water level data indicate a northward-northeastward sloping water table, occurring from 41.85 ft bgs in well V3-BG1 to 19.85 ft bgs in well V3-MW3.

5.1.2 Site Hydrogeology

The regional and local hydrogeologic settings of Vermont ANG Base are discussed in Section 3.5 of this report. Investigation derived hydrogeologic data for Sites 3 and 4 are presented in the following discussion of site hydrogeology.

One shallow subsurface aquifer, termed the upper overburden water/table aquifer, was identified at Sites 3 and 4. Preliminary water level data from Sites 3 and 4, determined from groundwater screening activities and installation of temporary piezometers (Site 4 only), indicated the depth to the water table varied with local topography and ranged from approximately 17 to 42 ft bgs in Site 3 and from approximately 18 to 24 ft bgs in Site 4. These preliminary data aided in the placement of confirmation monitoring wells. The following site-specific interpretation of shallow subsurface hydrogeology is based on two rounds of confirmation water level and free-product measurements from 8 groundwater monitoring wells; 2 background wells, 3 Site 3 wells, and 3 Site 4 wells. Measurement elevations (in ft AMSL) were determined from surveyed notches installed on the top of well casings. Water level rounds were conducted within approximately 24-hour periods from October 5-6, 1994, and from October 21-22, 1994. All water level and free-product measurement data are summarized in Table 5-1. The occurrence of fuel related free-product (JP-4 fuel) is discussed in Section 5.4.2.1.

Figures 5-6 and 5-7 present contour maps of water table elevations across Sites 3 and 4 based on October 5-6, 1994 and October 21-22, 1994 water level data, respectively. Water table elevation data collected October 5-6, 1994 were similar to the data collected October 21-22, 1994 data (with exception of free-product levels). Depths to the water table ranged

**Table 5-1 Water Level Elevation and Measured Free-Product Data,
Installation Restoration Program Sites 3 and 4,
Vermont Air National Guard Base**

Well	Screen Interval (ft) ^(a)	Depth to Water (ft) ^(a)		Ground Elevation ^(b)	TOC Elevation ^(b)	Water Level Elevation ^(b)		Measured Free Product (ft)	
		10/5-6/94	10/21-22/94			10/5-6/94	10/21-22/94	10/5-6/94	10/21-22/94
V3-BG1	40-50	41.91	42.12	325.90	325.38	283.99	283.78	0	0
V3-MW1	15.8-25.8	18.84	19.02	297.97	297.65	279.13	278.95	0 ^(d)	0 ^(d)
V3-MW2	15.05-25.05	17.71 ^(c)	17.28 ^(c)	297.65	297.28	279.94	280.37	2.69	0.01
V3-MW3	14.67-24.67	18.77	18.72	298.97	298.60	280.20	280.25	0 ^(d)	0 ^(d)
V4-BG1	19.14-29.14	21.90	22.09	288.31	287.93	266.41	266.22	0	0
V4-MW1	14.64-24.63	18.0	17.72 ^(c)	284.51	284.11	266.51	266.79	0 ^(d)	1.07
V4-MW2	15.67-25.66	19.31	19.55	283.81	283.51	264.50	264.26	0 ^(d)	0 ^(d)
V4-MW3	15.8-25.8	19.84	19.92	281.23	280.81	261.39	261.31	0	0

^(a) Feet (ft) below ground surface.

^(b) Ft above mean sea level.

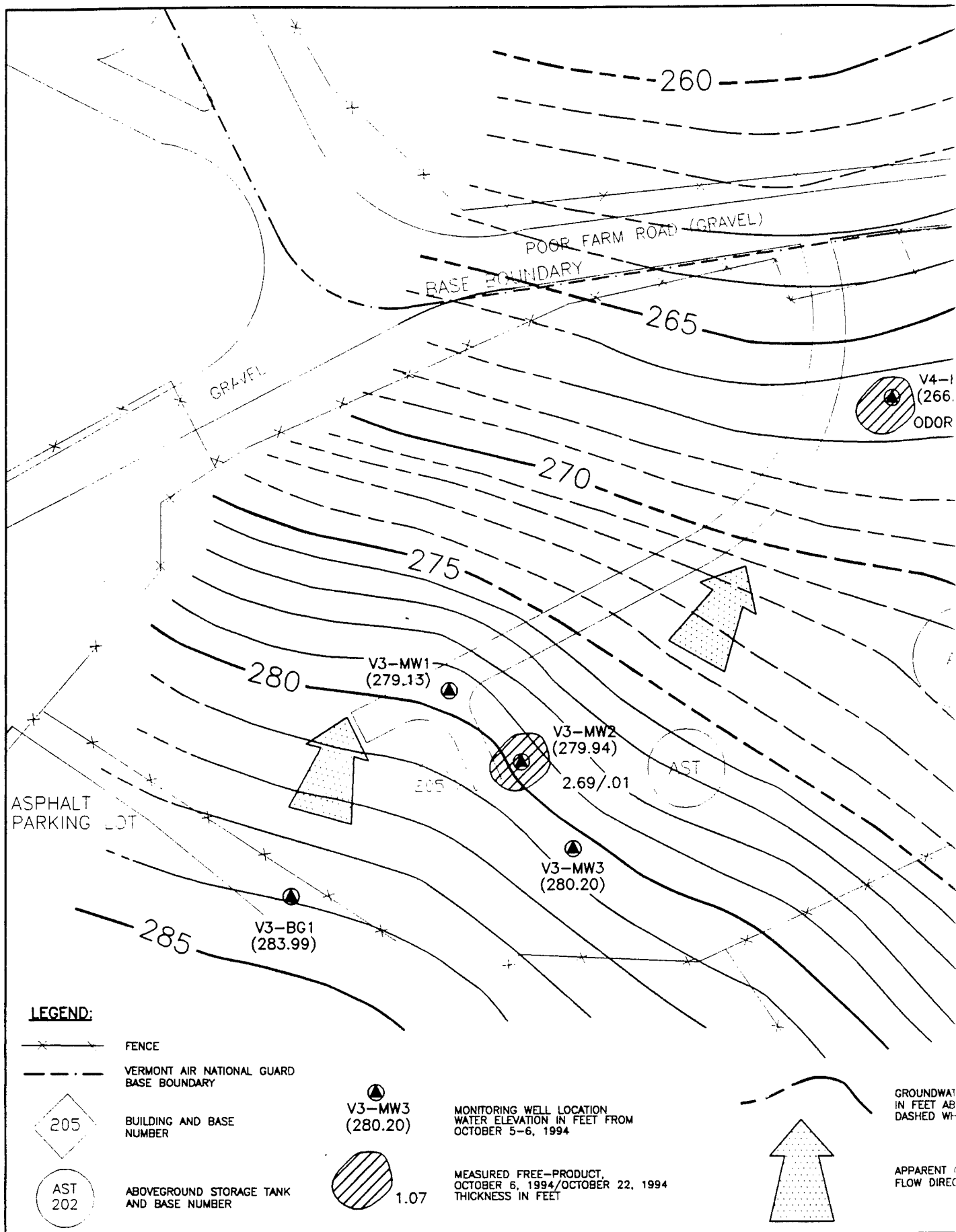
Depth to water corrected to account for depression from overlying free-product, according to the following equation:

True water level = Apparent water level - [Specific gravity of JP-4 (0.81) x Apparent thickness of free-product]

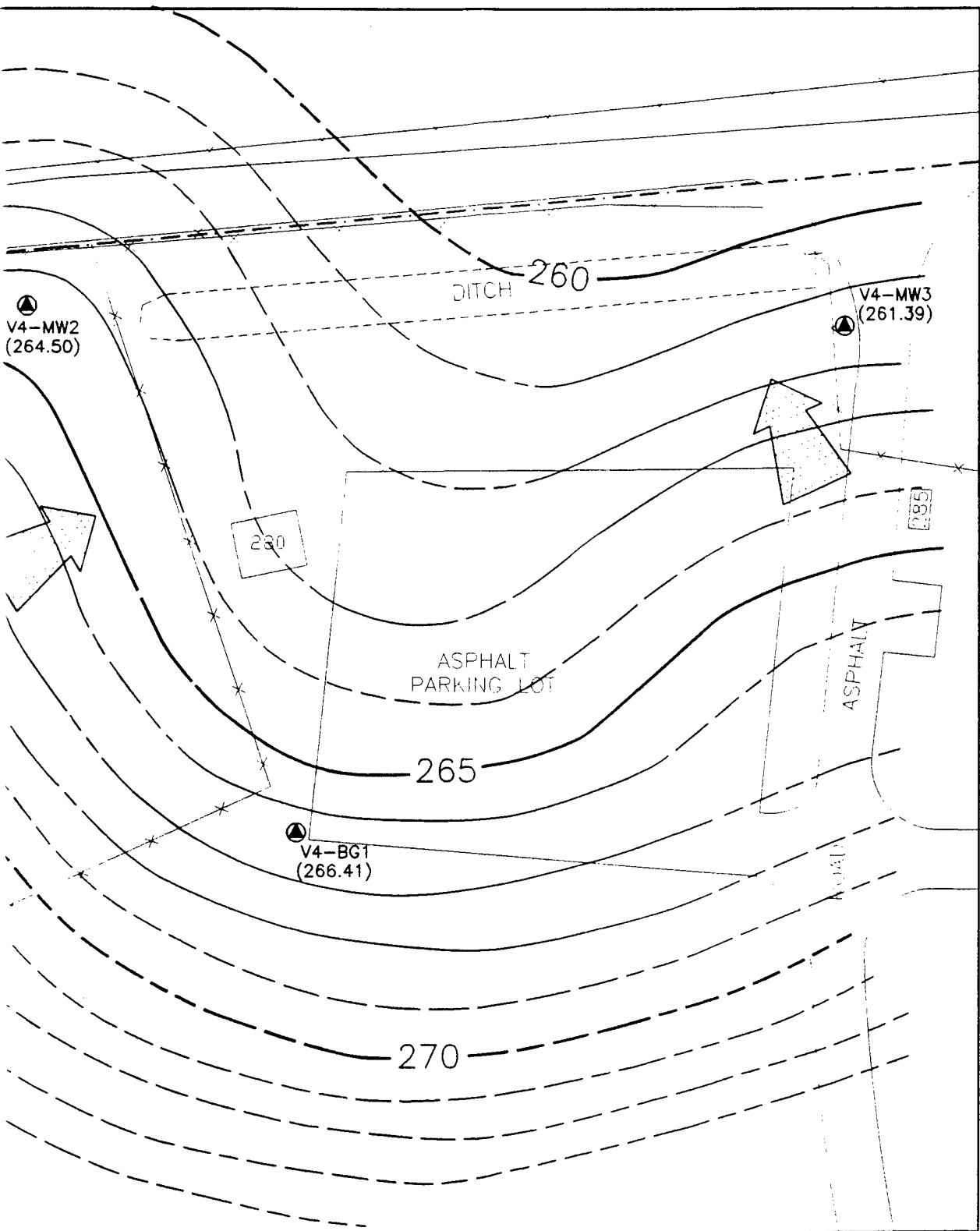
^(c) Hydrocarbon odor on oil/water level probe.

TOC

Top of Casing








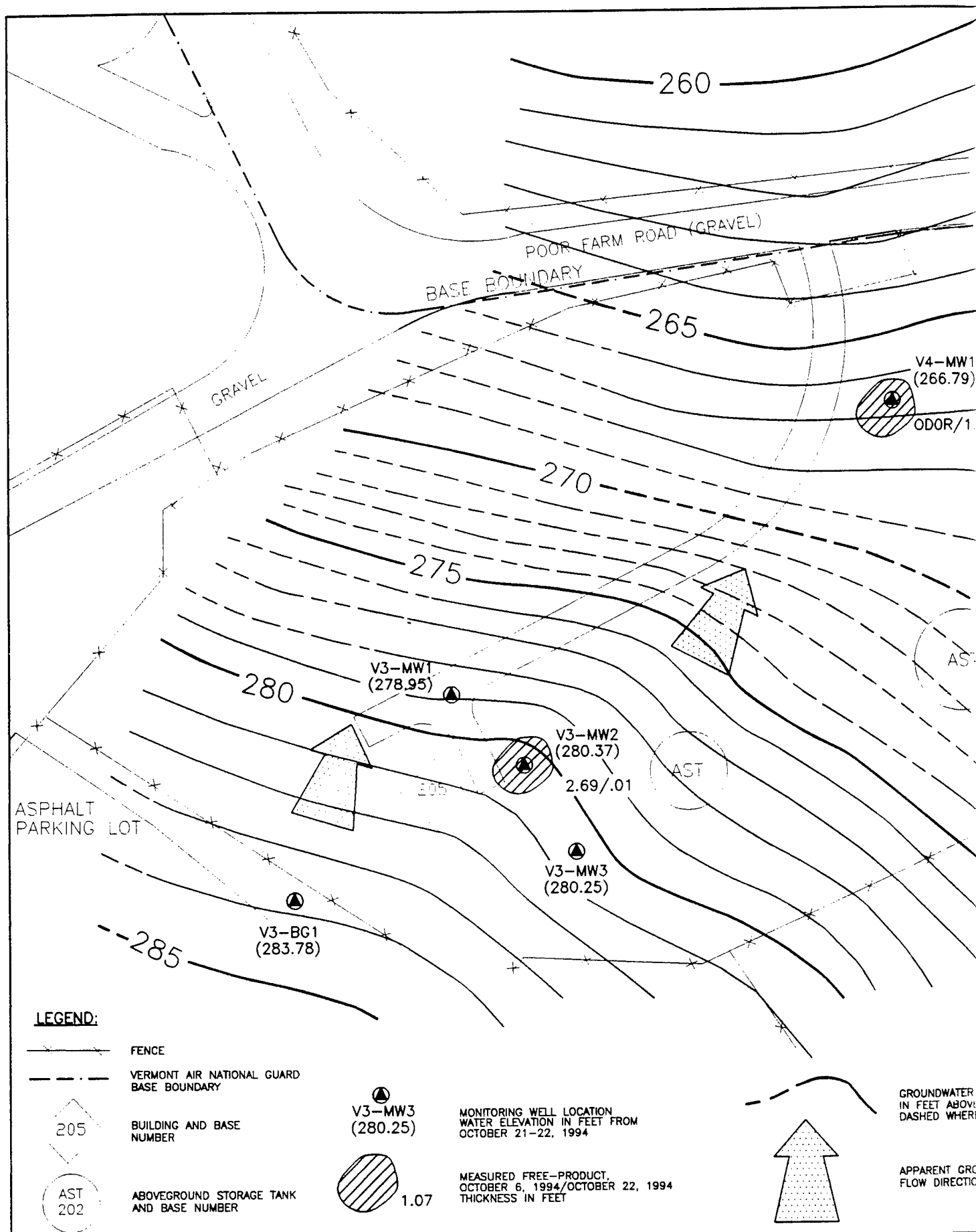
INTERVAL 1 FOOT)

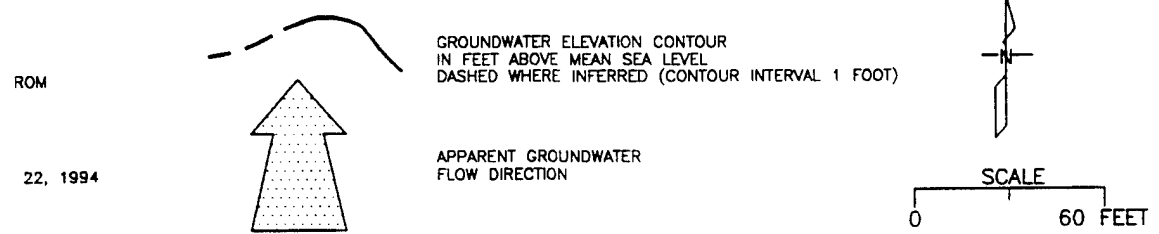
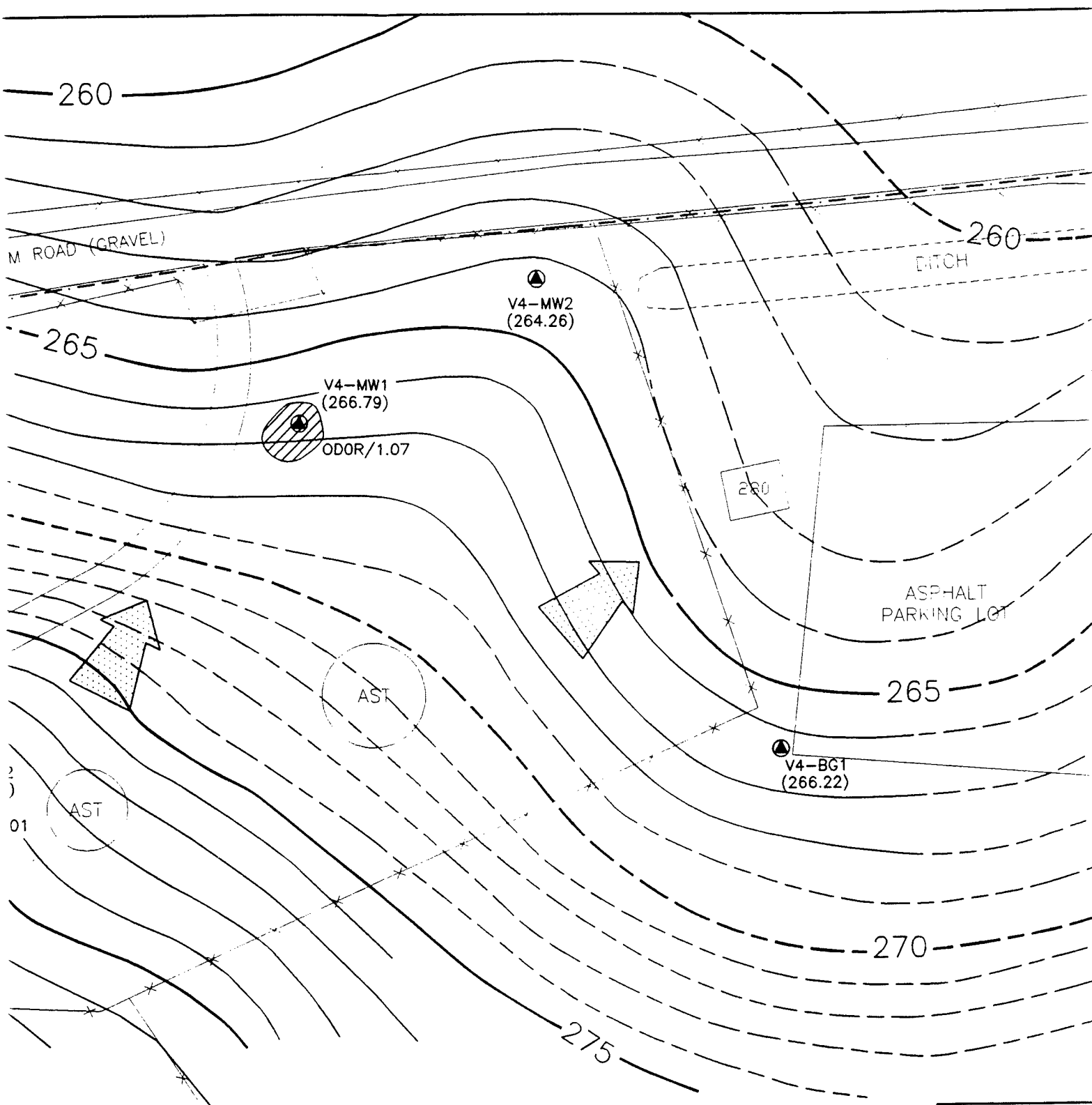
SCALE

0 60 FEET

<p>EARTH  TECH</p>	<p>INSTALLATION RESTORATION PROGRAM 158TH FIGHTER WING BURLINGTON, VERMONT</p>
<p>SITES 3 AND 4 OCTOBER 5-6, 1994 WATER TABLE ELEVATION CONTOUR MAP</p>	
<p>FIGURE 5-6</p>	

3



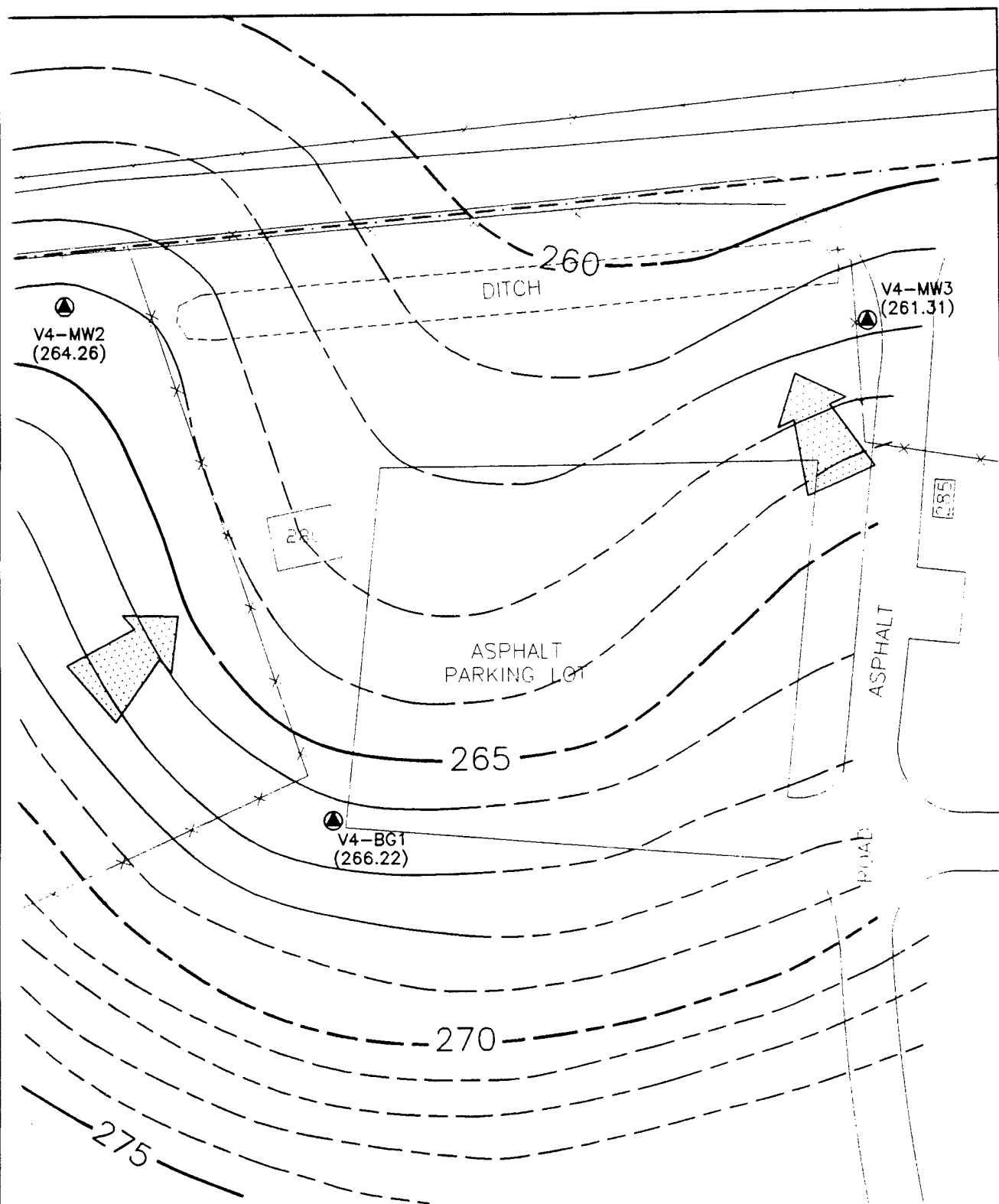


EARTH

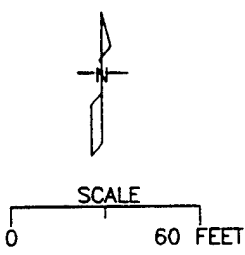
TEC

OCTOBER 21
ELEVATION

ROM
 22, 1994



IR
(OUR INTERVAL 1 FOOT)




EARTH  TECH	INSTALLATION RESTORATION PROGRAM 158TH FIGHTER WING BURLINGTON, VERMONT
<p style="text-align: center;"> SITES 3 AND 4 OCTOBER 21-22, 1994 WATER TABLE ELEVATION CONTOUR MAP </p>	

FIGURE 5-7

from 17.71 ft bgs in well V3-MW2 to 42.12 ft bgs in well V3-BG1. Both Figures 5-6 and 5-7 indicate a water table sloping northward-northeastward across Sites 3 and 4. Shallow unconfined groundwater apparently moves northward-northeastward from the POL facilities toward off-base property (the Griswold property), and subsequently towards the Winooski River. Both maps indicate approximated hydraulic gradients (based on water table contour spacing) ranging from 0.033 ft/ft to 0.125 ft/ft and an overall hydraulic gradient along a southwest to northeast trending profile, extending across Sites 3 and 4, of approximately 0.055 ft/ft.

5.2 ANALYTICAL RESULTS

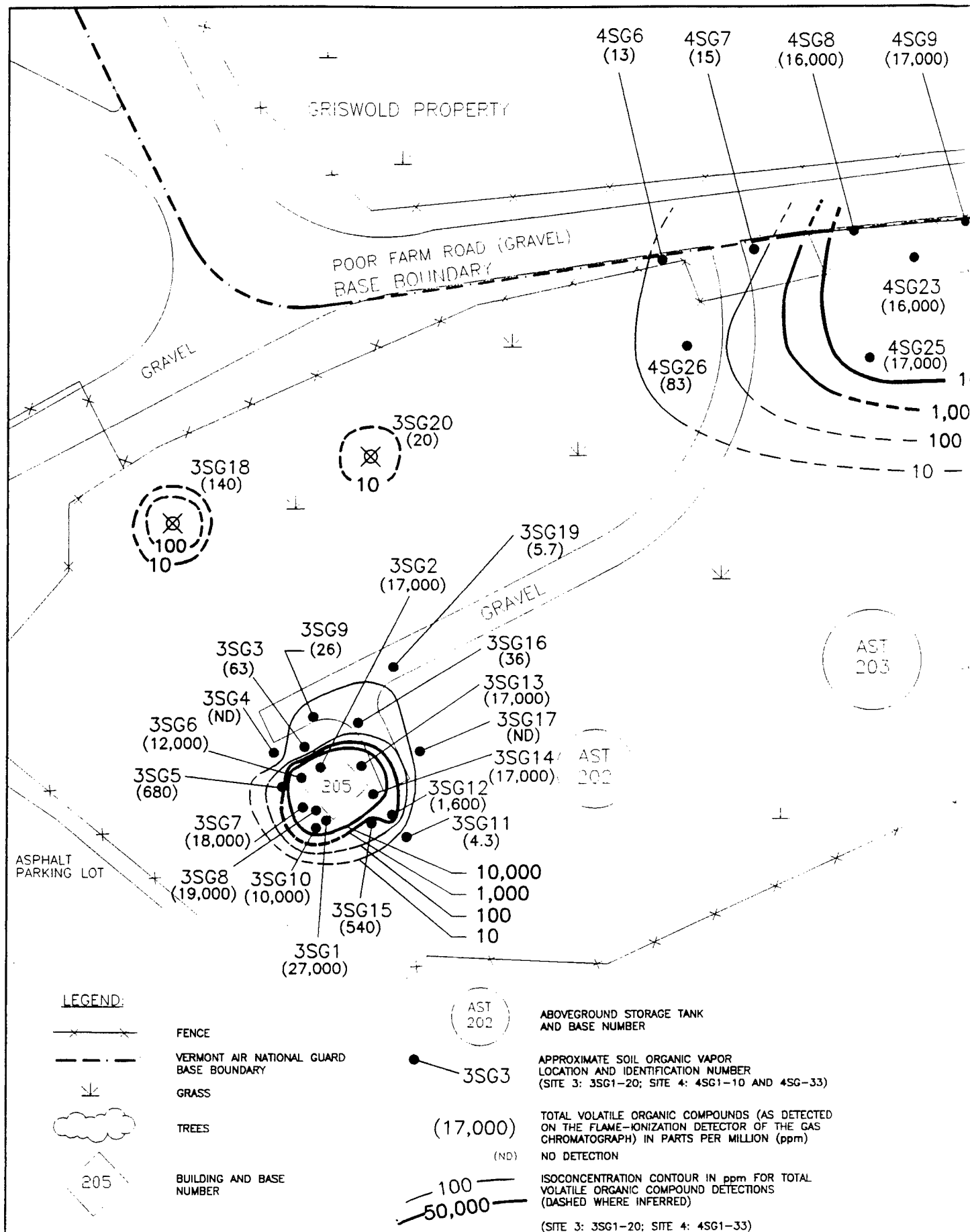
The primary purpose of this ASI was to confirm or deny the presence of fuel-related contamination at IRP Sites 3 and 4. Detailed delineation of the nature and extent of contamination, and characterization regarding possible remedial actions, were not within the scope of the site investigation. Preliminary determination of the nature and extent of contamination at IRP Sites 3 and 4 is based on field screening results and confirmation laboratory analytical results, which are presented in the following discussions. Confirmation laboratory analytical results include all detections except those qualified with a "B" (possible blank contamination) or "R" (unreliable result) data validation qualifier. Laboratory analytical data quality and data validation summaries are presented in Appendices H and I, respectively. Based on QA/QC sample results, the required majority of laboratory analytical data was determined acceptable and met the overall project DQOs; precision, accuracy, representativeness, comparability, and completeness (PARCCs). Some blank contamination (organic compounds and/or inorganic analytes) was noted in some QA/QC samples, but the impact on applicable analytical data was minor and no cross-contamination trends were identified.

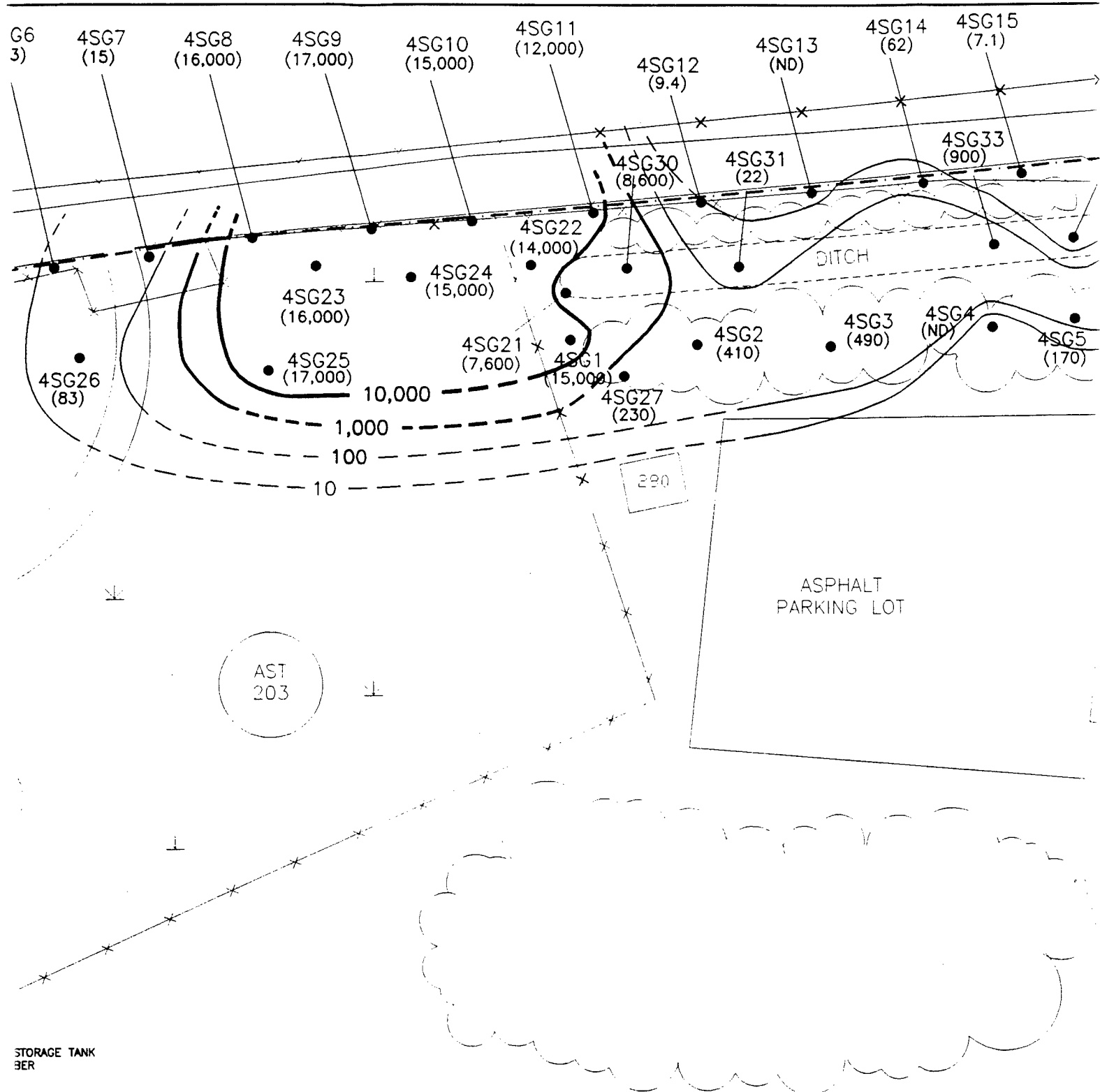
5.2.1 Field Screening Results

Field screening results consist of SOV surveys (soil gas sampling) and groundwater screening conducted at Sites 3 and 4. Soil gas and groundwater samples were analyzed for non-chlorinated and chlorinated target VOCs using a field laboratory GC. Non-chlorinated target VOCs consisted of BTEX. Chlorinated target VOCs consisted of 1,1-DCE, trans-1,2 DCE cis-1,2 DCE, 1,1,1-TCA, TCE, and PCE. A semiquantitative measurement of total VOCs detected on the FID of the GC was also recorded per sample. Field screening results were used to evaluate placement of confirmation activity soil borings and monitoring wells. All field screening results are presented in Appendix B. Field screening results are summarized by presenting total (FID) VOC detections, and other significant detections (if applicable), for soil gas and groundwater samples in the following discussions.

5.2.1.1 SOV Survey Results

Total VOC detections for soil gas samples from Sites 3 and 4 are presented in ppm concentrations in Figure 5-8. The highest soil gas detections were located in Site 3. Site-specific results are discussed below.





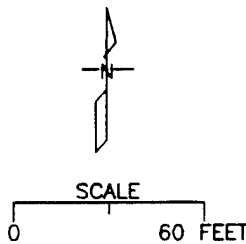
STORAGE TANK
BER

SOIL ORGANIC VAPOR
IDENTIFICATION NUMBER
20; SITE 4: 4SG1-10 AND 4SG-33)

ORGANIC COMPOUNDS (AS DETECTED
IONIZATION DETECTOR OF THE GAS
IN PARTS PER MILLION (ppm)

ON CONTOUR IN ppm FOR TOTAL
IC COMPOUND DETECTIONS
INFERRED)

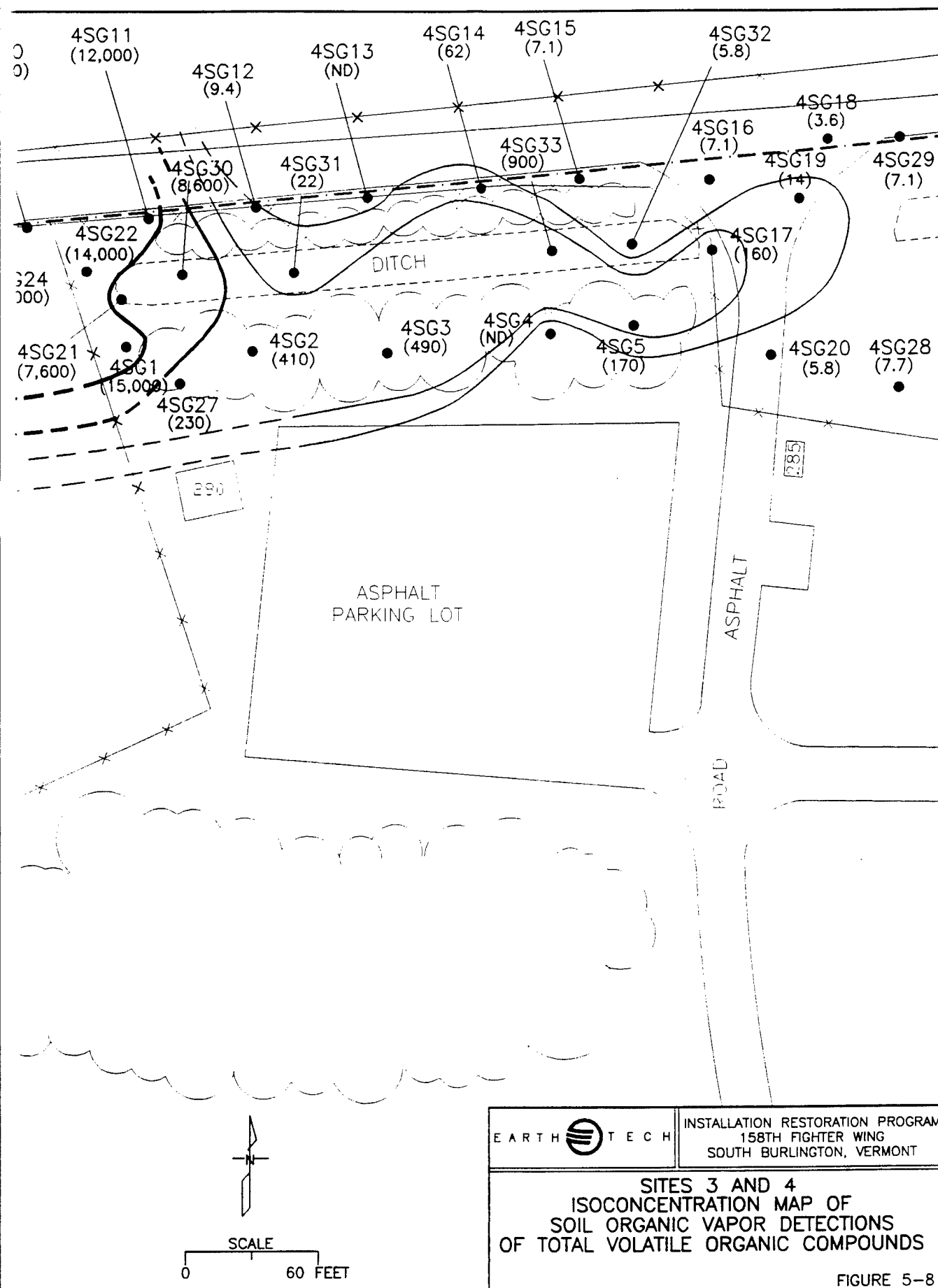
20; SITE 4: 4SG1-33)



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SITE
ISOCONCE
SOIL ORGANIC
OF TOTAL VOLAT

2



3

Site 3 - Dry Well

Twenty-one soil gas samples were collected and analyzed from Site 3. Twenty locations (3SG1 through 3SG20) were sampled in the vicinity of the dry well and pump house Building 205. A vertical profile was conducted at location 3SG1 from depths of 5 and 10 ft bgs. Based on the vertical profile results, a target sample depth of 10 ft bgs was selected for all subsequent locations at Site 3. The selected sampling depth was approximately 2 ft below the depth of the dry well (estimated to be 8 ft bgs), and approximately 7 to 9 ft above the water table (approximately 17 to 19 ft bgs), as indicated by subsequent confirmation activity results.

Detections of total VOCs were indicated in samples from 18 of 20 locations. No detections were noted in locations 3SG4 and 3SG17. Detections ranged from 4.3 ppm (3SG11) to 27,000 ppm (3SG1). Significant detections (in excess of 1000 ppm) were located in the immediate vicinity of the dry well and Building 205. Figure 5-8 presents an isoconcentration map of total VOC detections in soil gas at Site 3.

Low-level detections (less than 0.2 ppm) of chlorinated VOCs (TCE and PCE) were indicated in 10-foot samples from locations 3SG1, 3SG7, and 3SG8, in the vicinity of the dry well. Low-level detections of PCE were also indicated in the 5-foot sample from 3SG1. TCE detections ranged from 0.041 ppm (3SG7) to 0.17 ppm (3SG1). PCE detections ranged from 0.06 ppm (3SG1 - 10-foot sample) to 0.048 (3SG1 - 10-foot sample).

Site 4 - Drainage Ditch

Forty soil gas samples were collected and analyzed from Site 4. Thirty-three locations (4SG1 through 4SG33) were sampled in the vicinity of the base boundary drainage ditch and adjoining subsurface storm sewer piping. Vertical profiles were conducted at locations 4SG1 (5, 10, and 15 ft bgs), 4SG16 (10 and 15 ft bgs), and 4SG21 (5 and 10 ft bgs). Sampling depths varied locally to compensate for variations in topography. Based on the vertical profile results, target sample depths of 10 ft or 15 ft bgs were selected for most subsequent locations at Site 4. Four locations (4SG30 through 4SG33) were in the topographically low drainage ditch and were sampled from 5 ft bgs. Two locations were on a topographically high area on the east end of the site and were sampled from 20 ft bgs. The selected sampling depths were approximately 5 ft below the depth of subsurface storm sewer piping and the adjoining drainage ditch (both located approximately 5 ft bgs) and approximately 4 to 10 ft above the water table (approximately 18 to 24 ft bgs), as indicated by subsequent confirmation activity results.

Detections of total VOCs were indicated in samples from 31 of 33 locations. No detections were noted in locations 4SG4 and 4SG13. Detections ranged from 3.3 ppm (4SG28) to 17,000 ppm (4SG9 and 4SG25). Significant detections (in excess of 1000 ppm) were located in the western portion of the site, in the vicinity of the original storm sewer excavation area. Figure 5-8 presents an isoconcentration map of total VOC detections in soil gas at Site 4. No detections of chlorinated VOCs were indicated in soil gas samples from Site 4.

5.2.1.2 Groundwater Screening Results

Groundwater screening results for Sites 3 and 4 include detections for total VOCs and benzene. Groundwater screening detections of total VOCs and benzene are presented in Figures 5-8 and 5-9, respectively. The highest groundwater screening detections were located in Site 3. Site-specific results are discussed below.

Site 3 - Dry Well

Eight groundwater screening samples were collected and analyzed from Site 3. Eight locations (3GW1 through 3GW8) were sampled in the vicinity of the dry well and pumphouse Building 205. Selected sampling depths were located several ft below the apparent water table, which is located approximately 8 ft below the depth of the dry well (estimated to be 8 ft bgs).

Detections of total VOCs were indicated in all eight locations. Detections ranged from 0.19 ppm (3GW7) to 84,000 ppm (3GW3). Significant detections (in excess of 100 ppm) were located in the immediate vicinity of the dry well and Building 205. Figure 5-9 presents an isoconcentration map of total VOC detections in groundwater screening samples at Site 3.

The hydraulically downgradient extent of total VOC groundwater contamination apparently trends to the north; however, this interpretation is supported by only one sampling location (3GW8). No detections of chlorinated VOCs were indicated in groundwater samples from Site 3.

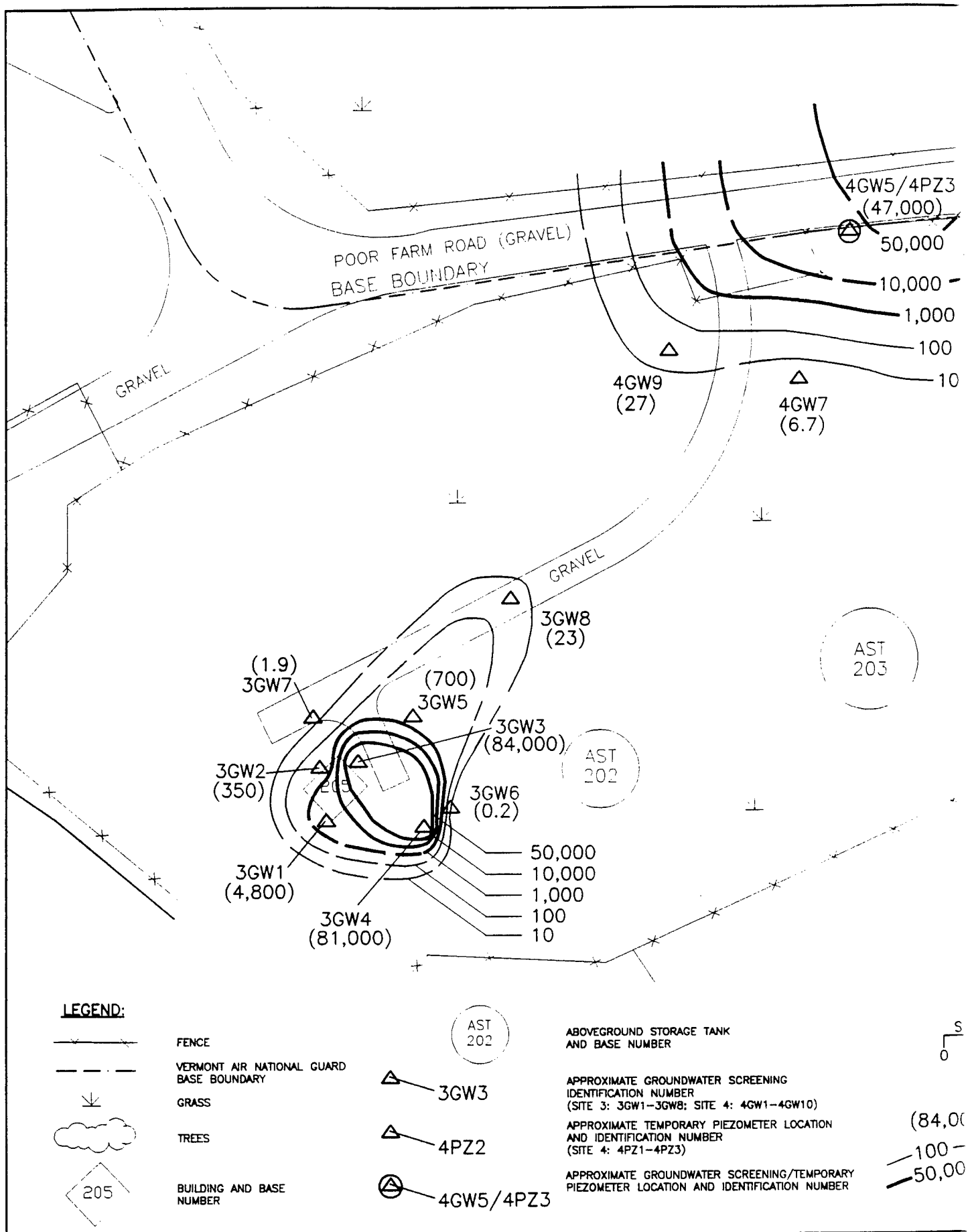
Benzene was detected at all eight locations. Detections ranged from 0.23 ppm (3GW6) to 14,000 ppm (3GW4). The highest detections (greater than 100 ppm) were located in the immediate vicinity of the dry well and Building 205. Figure 5-10 presents an isoconcentration map of benzene detections in groundwater at Site 3. The hydraulically downgradient extent of benzene groundwater contamination apparently trends to the north, as noted for total VOC groundwater contamination.

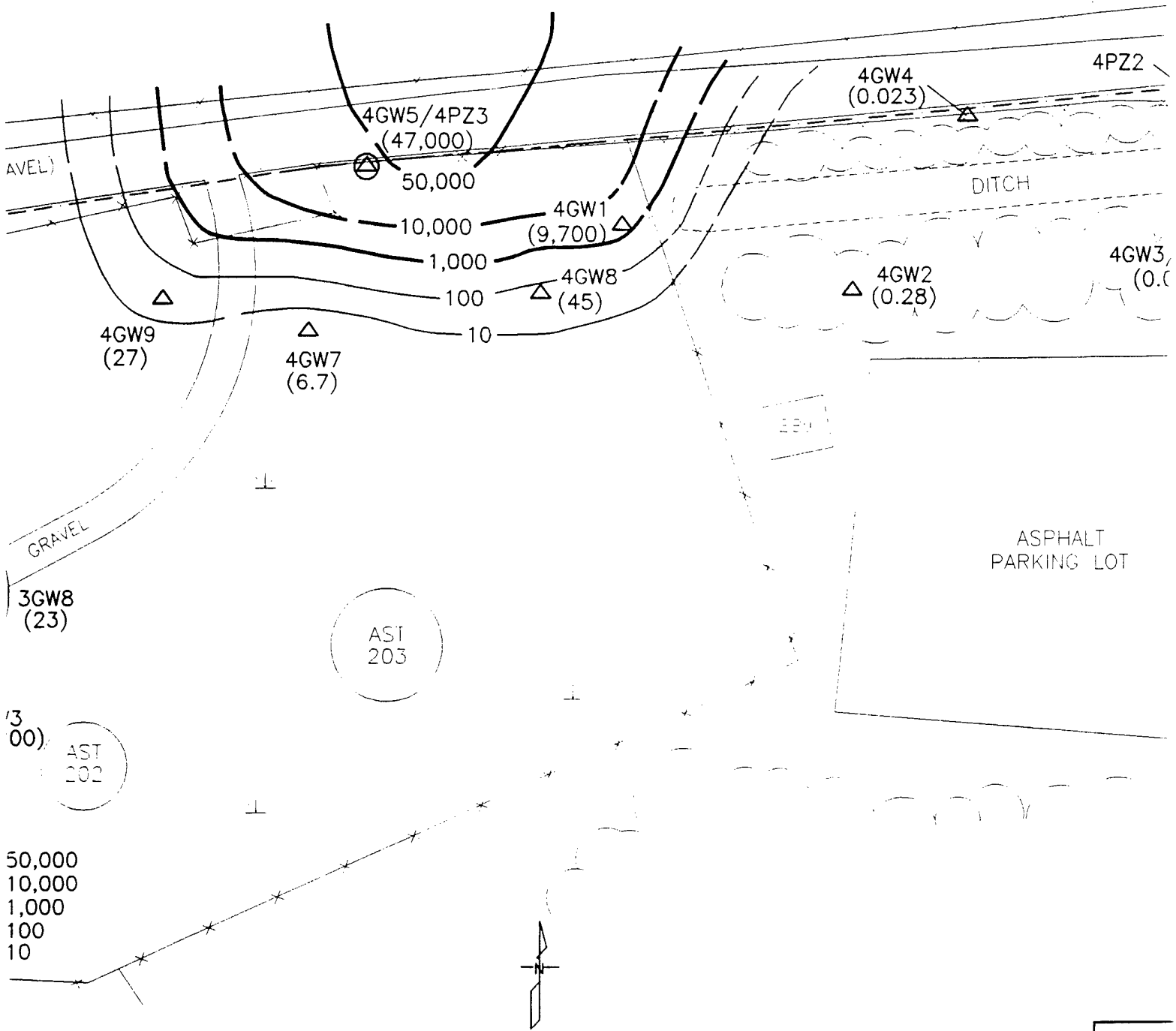
Site 4 - Drainage Ditch

Ten groundwater screening samples were collected and analyzed from Site 4. Ten locations (4GW1 through 4GW10) were sampled in the vicinity of the base boundary drainage ditch. Selected sampling depths were located several ft below the apparent water table, which is located approximately 14 ft below the depth of the drainage ditch and adjoining subsurface storm sewer piping (approximately 5 ft bgs).

Detections of total VOCs were indicated in all ten locations. Detections ranged from 0.04 ppm (4GW3) to 47,000 ppm (4GW5). Significant detections (in excess of 100 ppm) were located in the western portion of the site, in the vicinity of the original storm sewer excavation area. The highest detection at location 4GW5 is located on the base boundary, immediately south of Poor Farm Road. Figure 5-9 presents an isoconcentration map of total VOC detections in groundwater at Site 4. The hydraulically downgradient extent of groundwater contamination apparently trends off-site to the north, toward the Griswold property. No detections of chlorinated VOCs were indicated in groundwater samples from Site 4.

Benzene was detected in nine of ten locations. No benzene was detected at location 4GW6 in the easternmost area of the site. Detections ranged from 0.002 ppm (4GW4) to 9,300





ABOVEGROUND STORAGE TANK
AND BASE NUMBER

APPROXIMATE GROUNDWATER SCREENING
IDENTIFICATION NUMBER
(SITE 3: 3GW1-3GW8; SITE 4: 4GW1-4GW10)

APPROXIMATE TEMPORARY PIEZOMETER LOCATION
AND IDENTIFICATION NUMBER
(SITE 4: 4PZ1-4PZ3)

APPROXIMATE GROUNDWATER SCREENING/TEMPORARY
PIEZOMETER LOCATION AND IDENTIFICATION NUMBER

(84,000)

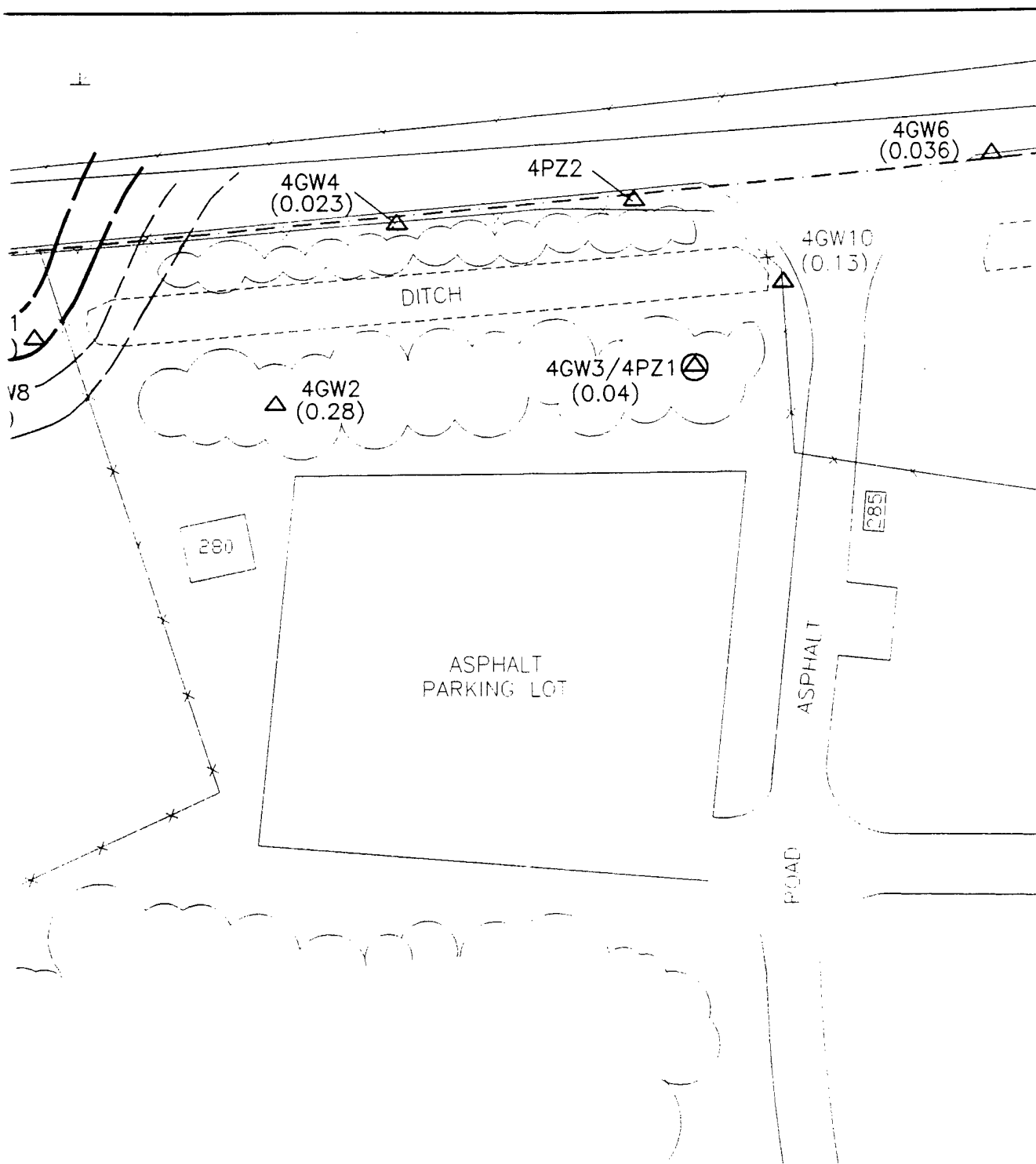
100
50,000

TOTAL VOLATILE ORGANIC COMPOUNDS (AS DETECTED
ON THE FLAME-IONIZATION DETECTOR OF THE GAS
CHROMATOGRAPH) IN PARTS PER MILLION (ppm)

ISOCONCENTRATION CONTOUR IN ppm FOR TOTAL
FOR TOTAL VOLATILE ORGANIC COMPOUND DETECTIONS
(DASHED WHERE INFERRED)

EARTH

GROU
OF TO



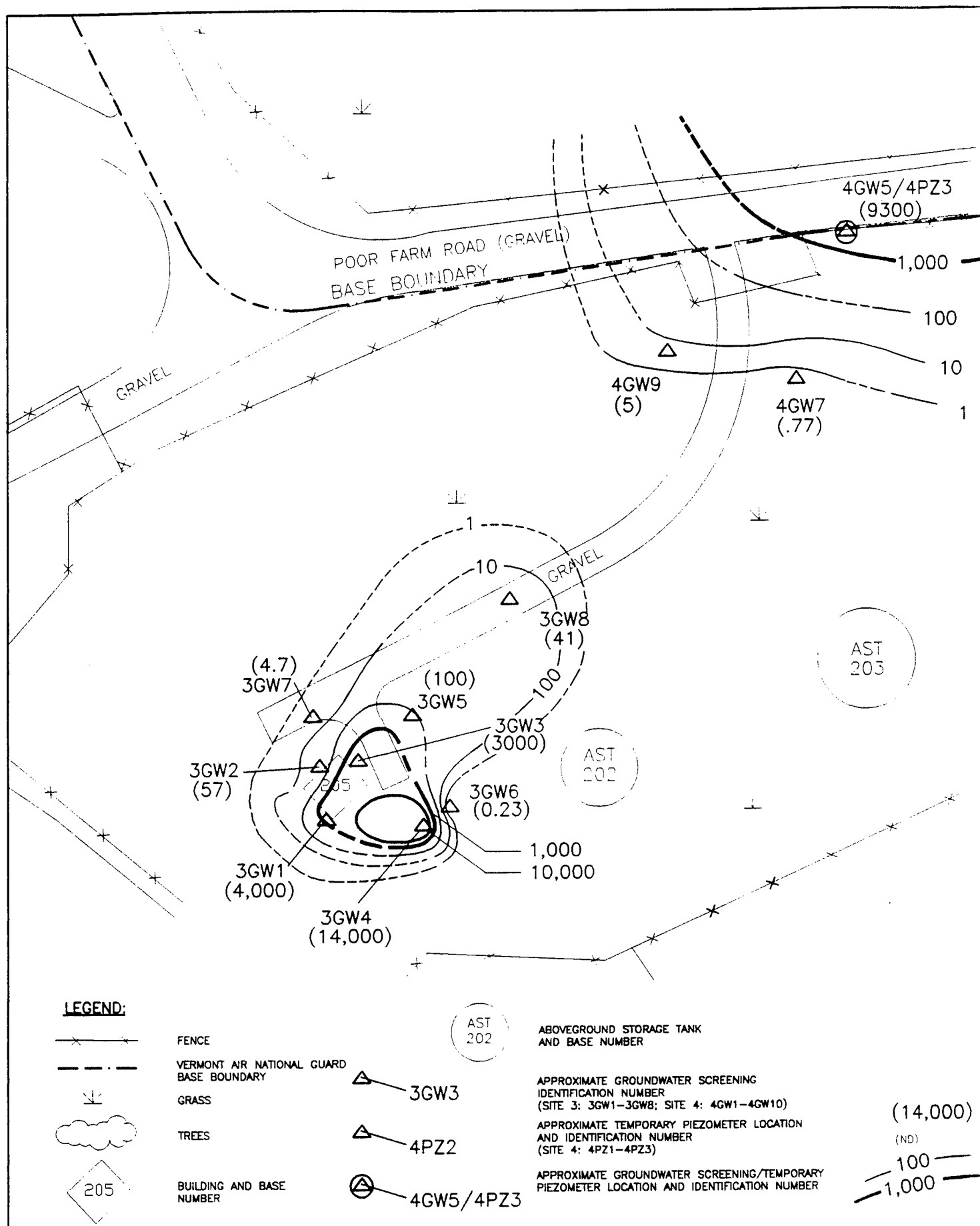
VOLATILE ORGANIC COMPOUNDS (AS DETECTED
 FLAME-IONIZATION DETECTOR OF THE GAS
 TOGRAPH) IN PARTS PER MILLION (ppm)
 CONCENTRATION CONTOUR IN ppm FOR TOTAL
 VOLATILE ORGANIC COMPOUND DETECTIONS
 WHERE INFERRED

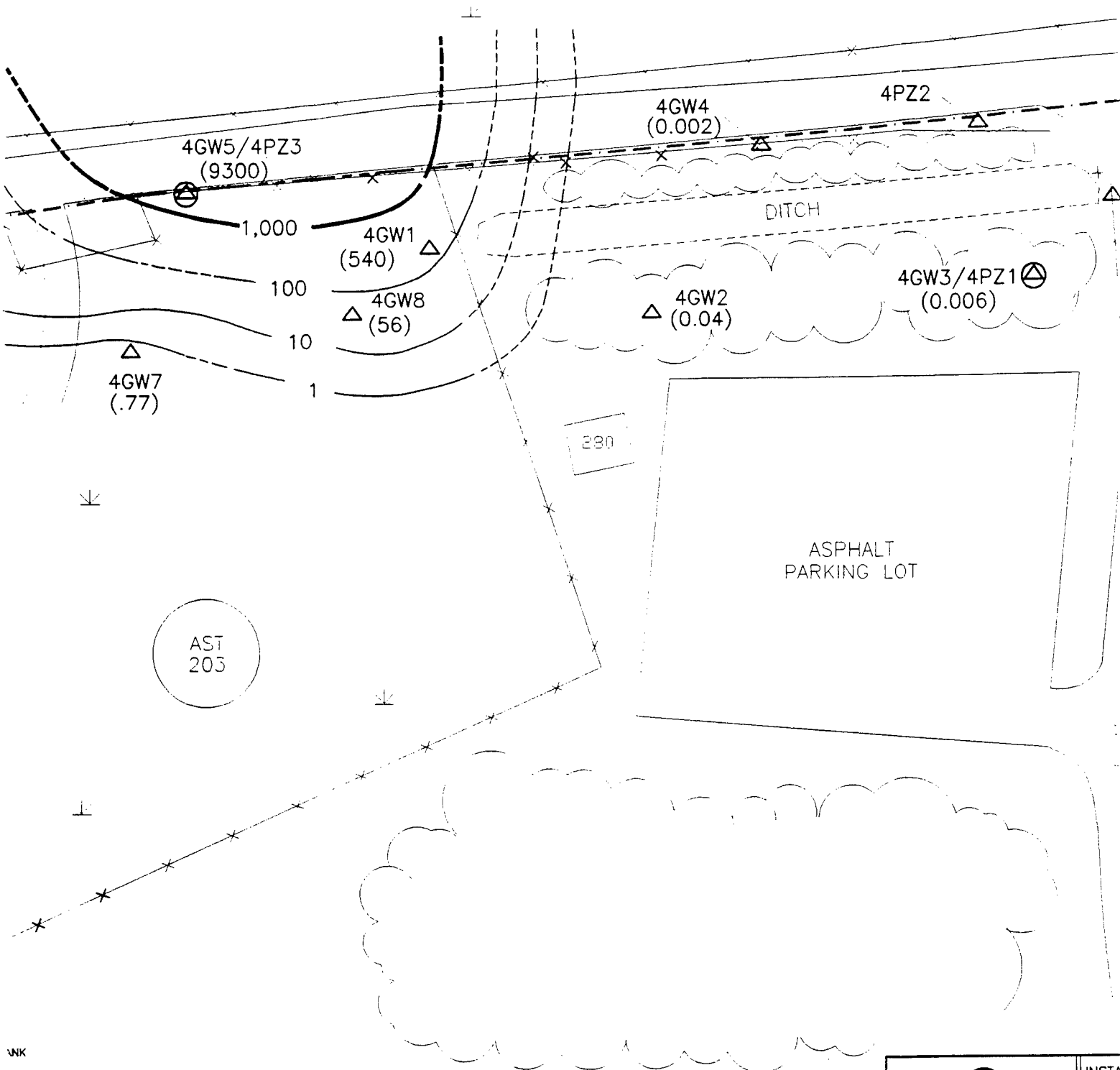
EARTH TECH

INSTALLATION RESTORATION PROGRAM
 158TH FIGHTER WING
 BURLINGTON, VERMONT

SITES 3 AND 4 ISOCONCENTRATION MAP OF GROUNDWATER SCREENING DETECTIONS OF TOTAL VOLATILE ORGANIC COMPOUNDS

FIGURE 5-9





UNK

R SCREENING

4: 4GW1-4GW10)

PIEZOMETER LOCATION

R

R SCREENING/TEMPORARY IDENTIFICATION NUMBER

(14,000)

(ND)

100


1,000

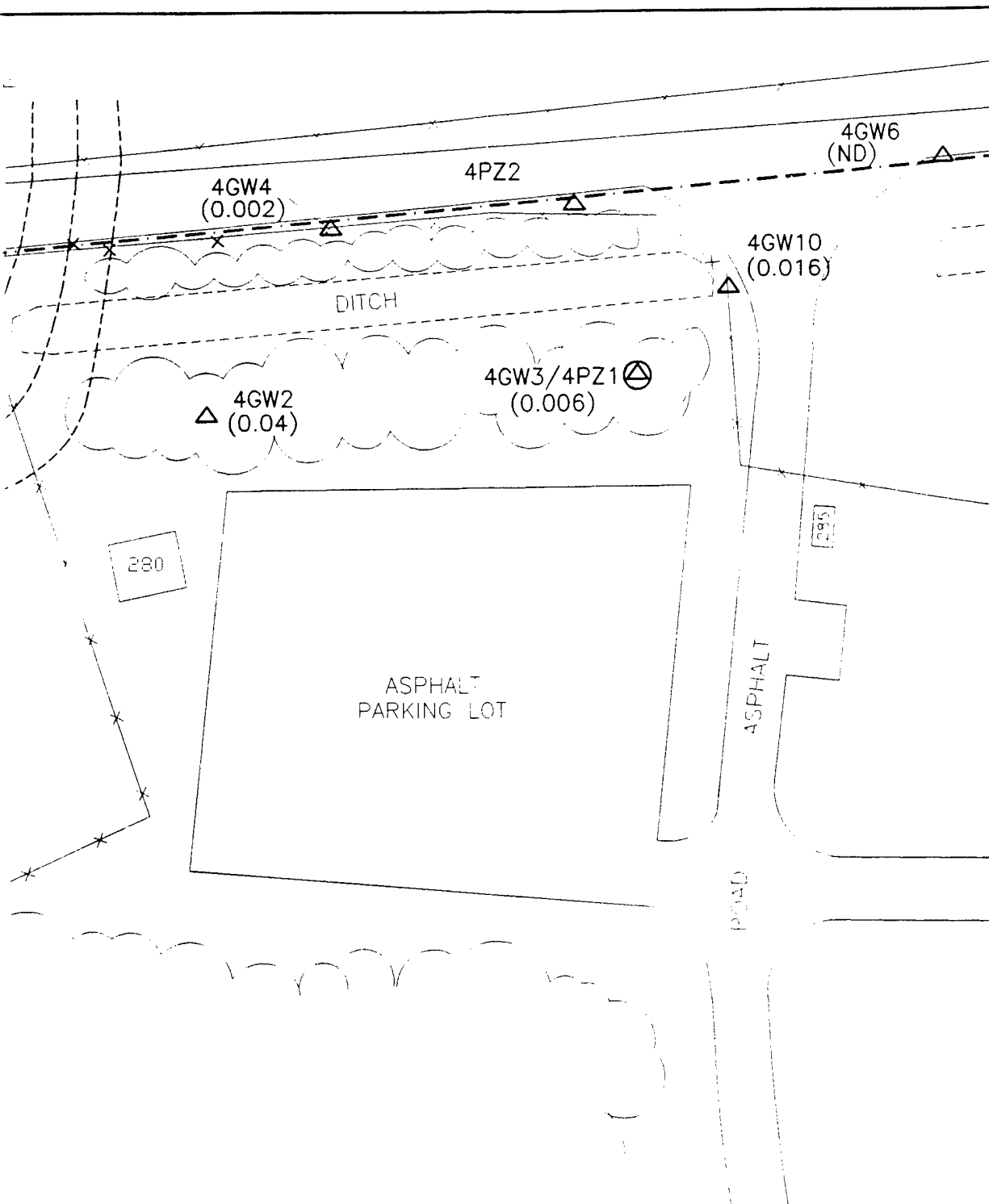
BENZENE DETECTION IN PARTS PER MILLION (ppm)

NOT DETECTED

ISOCONCENTRATION CONTOUR IN ppm FOR BENZENE CONCENTRATIONS (DASHED WHERE INFERRED)



EARTH  TECH	INSTA SC
SITES 3 AND 4 - MAP OF GROUNDW, DETECTIONS O	



IN PARTS PER MILLION (ppm)

CONTOUR IN ppm FOR
DETECTIONS
(RRED)

0 60 FEET

EARTH TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
SOUTH BURLINGTON, VERMONT

SITES 3 AND 4 - ISOCONCENTRATION
MAP OF GROUNDWATER SCREENING
DETECTIONS OF BENZENE

FIGURE 5-10

3

5-17

ppm (4GW5). The highest detections (greater than 100 ppm) were located in the vicinity of the original storm sewer excavation area. Figure 5-10 presents an isoconcentration map of benzene detections in groundwater at Site 3. The hydraulically downgradient extent of groundwater contamination apparently trends off-site to the north, toward the Griswold property.

5.2.3 Laboratory Analytical Results - Subsurface Soils

Excluding QA/QC samples, 30 subsurface soil samples were collected from Sites 3 and 4 (including background locations) and submitted for laboratory analysis for VOCs, SVOCs, TPH, and TAL metals. Subsurface soil samples were collected from site background and source area soil borings. Background borings were located in areas hydraulically up-gradient of suspected source areas. Source area borings were located in and proximal to suspected source areas based on site description data; Building 205 in Site 3 and the base boundary drainage ditch in Site 4. In Site 3, soil samples were collected from five source area soil borings (V3-B1 through V3-B5) and one background soil boring (V3-BG1) (Figure 5-1). In Site 4, soil samples were collected from six source area soil borings (V4-B1 through V4-B6) and one background soil boring (V4-BG1) (Figure 5-1). Subsurface soil samples were collected from vadose zone soils, from shallow subsurface to water table depths. Submitted sample depths ranged from 3 to 5 ft bgs to 38 to 40 ft bgs. At a minimum, two samples were submitted per boring, one from the near water table interface, and one from the sample interval nearest the surface or from the sample interval (other than the water table interface sample) exhibiting the highest PID screening detection of VOCs (if applicable). In some locations, including the two background locations, three soil samples were submitted to enable characterization of shallow, intermediate, and water table sample depths. Three soil samples were collected from background boring V3-BG1; from shallow subsurface to water table depths. Two soil samples were collected from four of the five Site 3 borings; V3-B1, V3-B2, V3-B3, and V3-B5. Three soil samples were collected from boring V3-B4. Three soil samples were collected from background boring V4-BG1; from shallow subsurface to water table depths. Two soil samples were collected from five of the six Site 4 borings; V4-B1, V4-B2, V4-B3, V4-B4, and V4-B6. Three soil samples were collected from boring V4-B5.

Laboratory analytical results for subsurface soils in Sites 3 and 4 are summarized in the following discussions of detected organic compounds and inorganic analytes in subsurface soil samples. Discussions of soil analytical results are presented with respect to the following soil boring locations: Site 3 - background and site area; Site 4 - background and site area. Soil analytical results per boring location are evaluated according to depth bgs and proximity to the water table.

5.2.3.1 Organics - Subsurface Soils

Organics in subsurface soil samples from Sites 3 and 4 (including background locations) are summarized in the following discussions of laboratory analytical detections of VOCs, SVOCs, and TPH. When applicable, organic compound detections are compared to ARARs; State of Vermont Residual Soil Values (Vermont 1992a). State of Vermont Residual Soil Values are presented in Appendix G; guidance values are not available for all organic compounds presented in this report. State of Vermont Residual Soil Values are available for many VOCs, a limited number of SVOCs, and are not available for TPH.

Detections of organic compounds (VOCs, SVOCs, and TPH) per soil boring and sample interval are presented in Table 5-2, and in Figure 5-11 (VOCs), Figure 5-12 (SVOCs), and Figure 5-13 (TPH). Detections of organic compounds in excess of State of Vermont Residual Soil values are highlighted in the aforementioned table and figures. State of Vermont Residual Soil Values are also presented in Table 5-2. Complete listings of compounds and laboratory analytical results are presented in Appendix J.

VOCs

Laboratory analyses for VOCs in subsurface soil samples were conducted according to EPA SW-846 Methods 8010/8020 (EPA 1986). VOC analyses consisted of analysis for halogenated VOCs by Method 8010 and analysis for aromatic VOCs by Method 8020. Analysis for dichlorobenzenes in soil was included under both Methods 8010 and 8020, as well as in the CLP 3/90 analyses for SVOCs. Detections of dichlorobenzenes in soils were limited to Method 8020 analyses. No detections of dichlorobenzenes were indicated under Method 8010 and CLP 3/90 analyses for SVOCs, which suggests the Method 8020 detections are suspect; particularly considering the reliability of GC/mass spectrometer analysis under CLP 3/90 methods. However, all detections of dichlorobenzenes are presented in the interest of presenting all valid data. Detections of VOCs in subsurface soil samples, reported in concentrations of micrograms per kilogram ($\mu\text{g}/\text{kg}$) or ppb, are summarized in Table 5-2 and Figure 5-11.

Detections of VOCs in soil samples from Site 3 background boring V3-BG1 were limited to low detections (less than the PQL) of methylene chloride (2.3 () to 2.6 () ppb). The detections were indicated in the shallow (3 to 5 ft bgs) and water table (38 to 40 ft bgs) sample intervals.

Detections of VOCs in soil samples from Site 3 borings ranged from low to high concentrations, some in excess of State of Vermont Residual Soil Values. Other than boring V3-B3, most shallow subsurface sample intervals (3 to 5 ft bgs) in Site 3 borings indicated no significant detections. High detections (in excess of 1,000 ppb) were mostly indicated in intermediate sample depths (8 to 10 and 13 to 15 ft bgs) in Site 3 borings. Detections of VOCs in borings V3-B1 and V3-B2 were low compared to respective Residual Soil Values. Of these, detections in the shallow sample intervals (3 to 5 ft bgs) were very low (less than 1 ppb and PQLs) and detections in the intermediate sample intervals (11 to 13 ft bgs) were higher (most were less than 100 ppb). Of the intermediate depth samples, 32 ppb benzene detected in the 11 to 13 ft sample from boring V3-B1 was the most significant. All detections in excess of Residual Soil Values were indicated in soil samples from borings V3-B3, V3-B4, and V3-B5. In these borings, detections exceeded some or all of the following soil guidance values: benzene (100 ppb), chlorobenzene (2,000 ppb), 1,2-dichlorobenzene (12,400 ppb), 1,3-dichlorobenzene (12,400), 1,4-dichlorobenzene (1,500 ppb), ethylbenzene (13,600 ppb), styrene (100 ppb), toluene (48,400 ppb), and total xylenes (dimethylbenzenes) (8,000 ppb). Detections exceeding Residual Soil Values in boring V3-B3 were indicated in shallow (3 to 5 ft bgs) and intermediate (13 to 15 ft bgs) sample intervals, and included 5,200 ppb chlorobenzene, 1,600 ppb 1,4-dichlorobenzene, 1,200 to 5,500 ppb styrene, and 8,400 to 10,400 ppb total xylenes. Detections exceeding Residual Soil Values in boring V3-B5 were limited to the intermediate (13 to 15 ft bgs) sample interval, and included 2,700 ppb chlorobenzene, 5,500 ppb styrene, and 47,600 ppb total xylenes. The highest VOC

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

Area Location		Site 3 Background						Site 3			
Sample Location		V3-BG1				V3-B1		V3-B2			
Sample Depth (ft bgs) Date Sampled Material Type		03-05 9/20/94 Silty Sand	18-20 9/20/94 Sand/Silt	*38-40 9/20/94 Sand/Silt	*38-40 D	03-05 9/13/94 Silty Sand	*11-13 9/13/94 Sand/Silt	*11-13 D	03-05 9/13/94 Silty Sand	*11-13 9/13/94 Sand/Silt	
Moisture Content %		12	8	19	25	8	12	16	9	14	
VOCs ¹ (ug/Kg) (a)	ARAR ²	POL									
Benzene	100	1.4						32			
Bromochloromethane		0.9									
Bromoform		0.9									
Chlorobenzene	2000	1.8				0.042 ()	48	44		14	
Chloroform		1.0						1.4 ()			
1,2 Dichlorobenzene	12400	1.4					110	260	0.53 ()	160	
1,3 Dichlorobenzene	12400	1.8					210	150	0.24 ()	130	
1,4 Dichlorobenzene	1500	1.8					200	210		220	
1,1 Dichloroethane (DCA)	100	0.8									
1,1 Dichloroethane (DCE)	140	0.8									
t-1,2-Dichloroethane (DCE)	1400	1.1									
1,2 Dimethylbenzene		1.2					63	210		210	
1,3 Dimethylbenzene		3.2					69	8.6 ()		8.7 ()	
1,4 Dimethylbenzene		3.2					69	8.6 ()		8.7 ()	
Total Xylenes	8000						201	227.2		227.4	
Ethylbenzene	13600	1.8					46	190		130	
Methylene Chloride	100	3.1		2.3 ()							
Methyl-t-butyl ether		11.3					81	1.1 ()			
Styrene	100	1.5					28	33		30	
Tetrachloroethane (PCE)	14	0.8									
Toluene	48400	5.3					34	64		14 ()	
1,1,1-Trichloroethane (TCA)	4000	2.7									
1,2,3-Trichloropropane		0.9									
VOCs ¹ Dilution Factor		1	1	1	1	1	5	5	1	5	

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

[illegible]

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

Area Location		Site 3									
Sample Location		V3-B3			V3-B4				V3-B5		
Sample Depth (ft bgs)	Date Sampled	03-05 9/13/94 Silty Sand	*13-15 9/13/94 Sand/Silt	03-05 9/13/94 Silty Sand	08-10 9/13/94 Sand/Silt	*13-15 9/13/94 Silty Sand	*13-15 D	03-05 9/13/94 Silty Sand	*13-15 9/13/94 Silt/ Sand		
Material Type		13	12	12	7	9	18	9	21		
Moisture Content %											
VOCs ¹ (ug/kg) (a)	ARAR ²	PQL									
Benzene	100	1.4									
Bromochloromethane		0.9									
Bromoform		0.9									
Chlorobenzene	2000	1.8									
Chloroform		1.0									
1,2 Dichlorobenzene	12400	1.4									
1,3 Dichlorobenzene	12400	1.8									
1,4 Dichlorobenzene	1500	1.8									
1,1 Dichloroethane (DCA)	100	0.8									
1,1 Dichloroethene (DCE)	140	0.8									
t-1,2-Dichloroethene (DCE)	1400	1.1									
1,2 Dimethylbenzene		1.2									
1,3 Dimethylbenzene		3.2									
1,4 Dimethylbenzene		3.2									
Total Xylenes	8000										
Ethylbenzene	13600	1.8									
Methylene Chloride	100	3.1									
Methyl-t-butyl ether		11.3									
Styrene	100	1.5									
Tetrachloroethene (PCE)	14	0.8									
Toluene	48400	5.3									
1,1,1-Trichloroethane (TCA)	4000	2.7									
1,2,3-Trichloropropane		0.9									
VOCs ¹ Dilution Factor		10-A/5-H	5	17 ¹ 5	20-A/5-H	100-A/5-H	100-A/5-H	1	20-A/5-H		

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

[illegible]

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

Area Location		Site 4 Background						Site 4			
Sample Location		V4-BG1				V4-B1		V4-B2			
Sample Depth (ft bgs)	Date Sampled	09-11 9/10/94 Sand/Silt	14-16 9/10/94 Sand/Silt	14-16 D	*19-21 9/10/94 Silty Sand	09-11 9/8/94 Sand/Silt	*17-19 9/8/94 Sand	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt		
Material Type											
Moisture Content %		4	3	8	20	17	13	4	21		
VOCs* (ug/kg) (a)	ARAR ²										
Benzene	100	0.059 ()	0.13 ()		0.11 ()			0.51 ()	3.4		
Bromochloromethane						0.29 ()	1.7 ()				
Bromoform		0.10 J ()									
Chlorobenzene	2000					0.14 ()	15000				
Chloroform								0.64 ()	0.89 ()		
1,2 Dichlorobenzene	12400			0.31 ()			21000				
1,3 Dichlorobenzene	12400			0.21 ()		18	2400		1.0 ()		
1,4 Dichlorobenzene	1500			0.34 ()			3100				
1,1 Dichloroethane (DCA)	100							0.065 ()	0.12 ()		
1,1 Dichloroethene (DCE)	140				0.20 ()						
t-1,2-Dichloroethene (DCE)	1400					0.20 ()					
1,2 Dimethylbenzene				0.31 ()			14000	1.2 ()	9.1		
1,3 Dimethylbenzene				0.37 ()			60000	1.4 ()	9.8		
1,4 Dimethylbenzene				0.37 ()			46000	1.4 ()	9.8		
Total Xylenes	8000			1.05			120000	4	28.7		
Ethylbenzene	13600			0.27 ()			50000	0.74 ()	7.4		
Methylene Chloride	100						9.4 ()				
Methyl-t-butyl ether						0.31 ()					
Styrene	100						32000				
Tetrachloroethene (PCE)	14										
Toluene	48400			0.23 ()				4.0 ()	9.7		
1,1,1-Trichloroethane (TCA)	4000										
1,2,3-Trichloropropane				0.056 ()							
VOCs* Dilution Factor		1	1	1	1	1	100-A-F-H	1	1		

Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base

Area Location		Site 4 Background					Site 4			
Sample Location		V4-BG1					V4-B1			
Sample Depth (ft bgs)	Date Sampled	09-11 9/10/94 Sand/Silt	14-16 9/10/94 Sand/Silt	14-16 D	*19-21 9/10/94 Silty Sand	09-11 9/8/94 Sand/Silt	*17-19 9/8/94 Sand	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt	
Material Type										
Moisture Content %		4	3	8	20	17	13	4	21	
SVOCs* (µg/kg) (a)	ARAR ²									
bis(2-Ethylhexyl)phthalate	CRQL									
	330									
Diethylphthalate	330									
Di-n-butylphthalate	330									
Di-n-octylphthalate	330									
Fluorene	330		35 ()	44 ()						
2-Methylnaphthalene	330						22000			
Naphthalene	330						13000		53 ()	
SVOCs* Dilution Factor		1	1	1	1	1	20	1	1	
TPH ³ (mg/kg) (a)	ARAR ²									
	POL									
Diesel	9.8						4800			
Gasoline	0.5						9200 J		2.1	
TPH ³ Dilution Factor		1	1	1	1	1	1	1	1	

**Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base**

Area Location		Site 4											
Sample Location		V4-B3			V4-B4		V4-B5			V4-B6			
Sample Depth (ft bgs)	Date Sampled	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt	09-11 9/8/94 Silt/Sand	*17-19 9/8/94 Sand	04-06 9/14/94 Sand/Silt	09-11 9/14/94 Sand/Silt	*17-19 9/14/94 Silt/Sand	*19-21 9/7/94 Sand	*24-26 9/7/94 Sand/Silt			
Moisture Content %		5	21	20	6	9	20	16	16	20			
VOCs (ug/Kg) (a)	ARAR ²	PQL											
Benzene	100	1.4	0.049 ()	0.062 ()	0.053 ()								
Bromochloromethane		0.9							0.44 ()				
Bromoform		0.9											
Chlorobenzene	2000	1.8				59		8000					
Chloroform		1.0	0.31 ()	0.52 ()	0.06 ()			3.9 ()		0.43 ()			
1,2 Dichlorobenzene	12400	1.4				72		22000					
1,3 Dichlorobenzene	12400	1.8				39	4.9	12000					
1,4 Dichlorobenzene	1500	1.8				92		31000					
1,1 Dichloroethane (DCA)	100	0.8			0.14 ()								
1,1 Dichloroethene (DCE)	140	0.8											
t-1,2-Dichloroethene (DCE)	1400	1.1								0.41 ()			
1,2 Dimethylbenzene		1.2	0.69 ()	0.90 ()		36		21000					
1,3 Dimethylbenzene		3.2		0.85 ()		21	1.5 ()	48000					
1,4 Dimethylbenzene		3.2		0.85 ()		21	1.5 ()	26000					
Total Xylenes	8000			2.6		7.8	3	95000					
Ethylbenzene	13600	1.8				53		26000					
Methylene Chloride	100	3.1				15 ()		30 ()					
Methyl-t-butyl ether		11.3											
Styrene	100	1.5				64	1.4 ()	7500					

Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base

Area Location		Site 4									
Sample Location		V4-B3		V4-B4		V4-B5		V4-B6			
Sample Depth (ft bgs)	Date Sampled	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt	09-11 9/8/94 Silt/Sand	*17-19 9/8/94 Sand	04-06 9/14/94 Sand/Silt	09-11 9/14/94 Sand/Silt	*17-19 9/14/94 Silt/Sand	*19-21 9/7/94 Sand	*24-26 9/7/94 Sand/Silt	
Material Type		5	21	20	6	9	20	16	16	20	
Moisture Content %											
VOCs ¹ (ug/Kg) (a)	ARAR ²	PQL									
Tetrachloroethene (PCE)	14	0.8									
Toluene	48400	5.3	1.7 ()	5.4 ()			0.47 ()	4300			
1,1,1-Trichloroethane (TCA)	4000	2.7									
1,2,3-Trichloropropane		0.9									
VOCs ¹ Dilution Factor			1	1	5	1	1	50-A/5-H	1	1	

Table 5-2 Laboratory Detections of Organic Compounds in Subsurface Soil Samples
Vermont Air National Guard Base

Area Location		Site 4									
Sample Location		V4-B3		V4-B4		V4-B5			V4-B6		
Sample Depth (ft bgs)	Date Sampled	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt	09-11 9/8/94 Silt/Sand	*17-19 9/8/94 Sand	04-06 9/14/94 Sand/Silt	09-11 9/14/94 Sand/Silt	*17-19 9/14/94 Silt/Sand	*19-21 9/7/94 Sand	*24-26 9/7/94 Sand/Silt	
Moisture Content %		5	21	20	6	9	20	16	16	20	
SVOCs ² (ug/kg) (a)											
bis(2-Ethylhexyl)phthalate											
Diethylphthalate											
Di-n-butylphthalate											
Di-n-butylphthalate											
Fluorene								58 ()			
2-Methylnaphthalene								3900 *			
Naphthalene								480			
SVOCs ² Dilution Factor		1	1	1	1	1	1	1 ¹ 2	1	1	
TPH ³ (mg/kg) (a)											
Diesel								2700			
Gasoline								4100 J			
TPH ³ Dilution Factor		1	1	1	1	1	1	1	1	1	

- 1 VOCs - Volatile Organic Compounds - analyzed by U.S. Environmental Protection Agency (EPA) Methods 8010/8020. Analyses for dichlorobenzenes were included under both Method 8010 (Halogenated) and 8020 (Aromatic). Detections were limited to Method 8020 analyses. Xylenes are listed as dimethylbenzenes; 1,2-dimethylbenzene = ortho-xylene; 1,3-dimethylbenzene = meta-xylene; 1,4-dimethylbenzene = para-xylene. All concentrations in micrograms/kilograms (ug/kg) or parts per billion (ppb).
- 2 ARAR - Applicable or Relevant and Appropriate Requirement; 1992 State of Vermont Residual Soil Value in ug/kg or ppb; equivalent to 20 x respective 1988 State of Vermont Groundwater Quality Enforcement Standard. Blanks indicate no ARAR.
- 3 SVOCs - Semivolatile Organic Compounds analyzed by - EPA Contract Laboratory Method (CLP) Method (3/90). SVOC analyses included dichlorobenzenes. All concentrations in ug/kg or ppb.
- 4 TPH - Total Petroleum Hydrocarbons - analyzed by California Modified Method 8015. All concentrations in milligrams/kilogram (mg/kg) or parts per million (ppm).

(a) No entry indicates no detection.

CRQL Contract Required Quantitation Limit. PQL - Practical Quantitation Limit. Values for CRQL and PQL represent only low soil matrix. Use the following equation to calculate the sample quantitation limit for each individual sample: (CRQL or PQL) * Dilution Factor / (100 - % moisture) / 100.

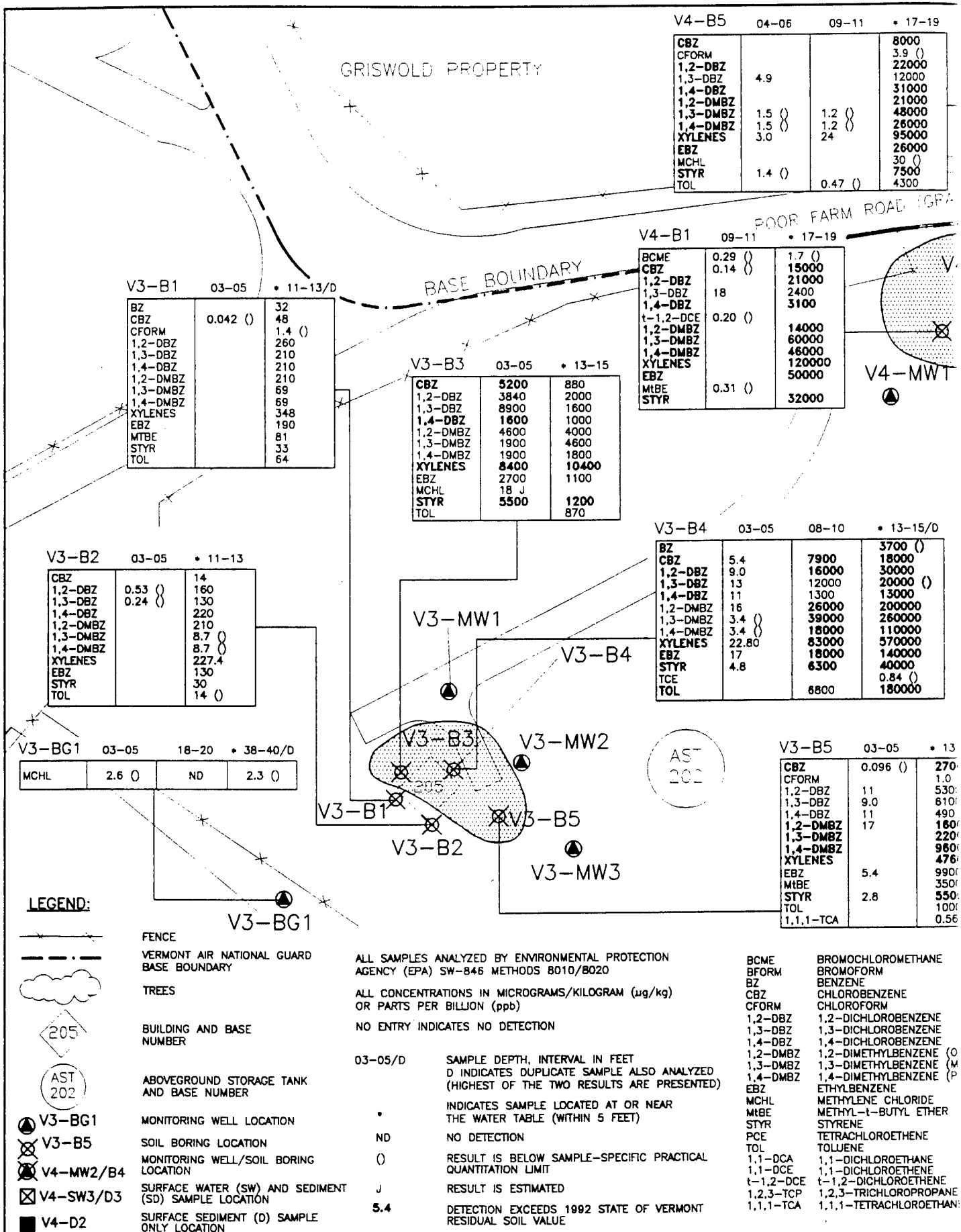
Shaded square containing detection indicates concentration is above 1992 State of Vermont Residual Soil Value.

Sample Depth: ft - feet, bgs - below ground surface, D - Duplicate sample, and * indicates sample located at or near the water table (within 5 feet).

() Result is below the sample-specific PQL or CRQL.

J Result is estimated

Dilution Factor: 100-A/5-H 1st value (100-A) aromatic VOCs; 2nd value (5-H) - halogenated VOCs. Indicates additional compound - specific dilution (e.g. 100). Not a data qualifier.



V4-B5 04-06 09-11 • 17-19

CBZ			8000
CFORM			3.9 ()
1,2-DBZ			22000
1,3-DBZ	4.9		12000
1,4-DBZ			31000
1,2-DMBZ			21000
1,3-DMBZ	1.5 ()	1.2 ()	48000
1,4-DMBZ	1.5 ()	1.2 ()	26000
XYLENES	3.0	24	95000
EBZ			26000
MCHL	1.4 ()		30 ()
STYR			7500
TOL		0.47 ()	4300

V4-B4 09-11 • 17-19

BZ	0.053 ()	59
CFORM	0.60 ()	72
1,2-DBZ		39
1,3-DBZ		92
1,4-DBZ		
1,1-DCE	0.14 ()	36
1,2-DMBZ		21
1,3-DMBZ		21
1,4-DMBZ		78
XYLENES		53
EBZ		15
MCHL		64
STYR	5.4 ()	
TOL		

V4-B1 09-11 • 17-19

BCME	0.29 ()	1.7 ()
CBZ	0.14	1500
1,2-DBZ	18	21000
1,3-DBZ		2400
1,4-DBZ		3100
t-1,2-DCE	0.20 ()	14000
1,2-DMBZ		60000
1,3-DMBZ		46000
1,4-DMBZ		120000
XYLENES		50000
EBZ	0.31 ()	
MIBE		
STYR		32000

POOR FARM ROAD (GRAVEL)

V4-B5

V4-MW2/B4

V4-SW3/D3

DITCH V4-

V4-B2

V4-B3

V4-B6

V4-MW1

V4-B2 • 14-16 • 19-21

BZ	0.51 ()	3.4
CFORM	0.64 ()	0.89 ()
1,3-DBZ		1.0 ()
1,1-DCA	0.065 ()	0.12 ()
1,2-DMBZ	1.2 ()	9.1
1,3-DMBZ	1.4 ()	9.8
1,4-DMBZ	1.4 ()	9.8
XYLENES	4.0	28.7
EBZ	0.74 ()	7.4
TOL	4.0 ()	9.7

V4-B6 • 19-21

BCME	0.44 ()
CFORM	
t-1,2-DCE	

V3-B4 03-05 08-10 • 13-15/D

BZ			3700 ()
CBZ	5.4	7900	18000
1,2-DBZ	9.0	16000	30000
1,3-DBZ	13	12000	20000 ()
1,4-DBZ	11	1300	13000
1,2-DMBZ	16	26000	200000
1,3-DMBZ	3.4 ()	39000	260000
1,4-DMBZ	3.4 ()	18000	110000
XYLENES	22.80	83000	570000
EBZ	17	18000	140000
STYR	4.8	6300	40000
TCE			0.84 ()
TOL		6800	180000

AST 203

V4-B3 • 14-16 • 19-21

BZ	0.049 ()	0.062 ()
CFORM	0.31 ()	0.52 ()
1,2-DMBZ	0.69 ()	0.90 ()
1,3-DMBZ		0.85 ()
1,4-DMBZ		0.85 ()
XYLENES	0.69	2.6
TOL		1.7 ()

ASPHALT PARKING LOT

V4-BG1

V3-B5 03-05 • 13-15

CBZ	0.096 ()	2700
CFORM		1.0 ()
1,2-DBZ	11	5300
1,3-DBZ	9.0	6100
1,4-DBZ	11	490
1,2-DMBZ	17	16000
1,3-DMBZ		22000
1,4-DMBZ		9600
XYLENES		47600
EBZ	5.4	9900
MIBE		3500
STYR	2.8	5500
TOL		10000
1,1,1-TCA		0.56 ()

V4-BG1 09-11 14-16/D • 19-21

BZ	0.059 ()	0.13 ()	0.11 ()
CFORM	0.10 ()		
1,2-DBZ		0.3 ()	
1,3-DBZ		0.21 ()	
1,4-DBZ		0.34 ()	
1,1-DCE			0.20 ()
1,2-DMBZ		0.31 ()	
1,3-DMBZ		0.37 ()	
1,4-DMBZ		0.37 ()	
XYLENES		1.05	
EBZ		0.27 ()	
TOL		0.23 ()	
1,2,3-TCP		0.056 ()	

PROTECTION

20

GRAM (µg/kg)

N FEET
MPLE ALSO ANALYZED
ULTS ARE PRESENTED)

AT OR NEAR
5 FEET)

-SPECIFIC PRACTICAL

STATE OF VERMONT

BCME	BROMOCHLOROMETHANE
BFORM	BROMOFORM
BZ	BENZENE
CBZ	CHLOROBENZENE
CFORM	CHLOROFORM
1,2-DBZ	1,2-DICHLOROBENZENE
1,3-DBZ	1,3-DICHLOROBENZENE
1,4-DBZ	1,4-DICHLOROBENZENE
1,2-DMBZ	1,2-DIMETHYLBENZENE (O-XYLENE)
1,3-DMBZ	1,3-DIMETHYLBENZENE (M-XYLENE)
1,4-DMBZ	1,4-DIMETHYLBENZENE (P-XYLENE)
EBZ	ETHYLBENZENE
MCHL	METHYLENE CHLORIDE
MIBE	METHYL-t-BUTYL ETHER
STYR	STYRENE
PCE	TETRACHLOROETHENE
TOL	TOLUENE
1,1-DCA	1,1-DICHLOROETHANE
1,1-DCE	1,1-DICHLOROETHENE
t-1,2-DCE	t-1,2-DICHLOROETHENE
1,2,3-TCP	1,2,3-TRICHLOROPROPANE
1,1,1-TCA	1,1,1-TETRACHLOROETHANE

APPROXIMATE AREA OF SOIL CONTAMINATION:
VOLATILE ORGANIC COMPOUNDS IN EXCESS
OF 1992 STATE OF VERMONT RESIDUAL
SOIL VALUES



SCALE

0 60 FEET

EARTH

LABORATORY
COMPOUND

2

V4-B4 09-11 • 17-19

BZ	0.053 ()	59
CBZ		
CFORM	0.60 ()	72
1,2-DBZ		39
1,3-DBZ		92
1,4-DBZ		
1,1-DCE	0.14 ()	36
1,2-DMBZ		21
1,3-DMBZ		21
1,4-DMBZ		78
XYLENES		53
EBZ		15 ()
MBHL		64
STYR		
TOL	5.4 ()	

V4-D1

DITCH

V4-D2

V4-MW3

V4-SW3/D3

V4-B2

V4-B3

V4-B6

4-16 • 19-21

51 ()	3.4
64 ()	0.89 ()
	1.0 ()
365 ()	0.12 ()
2 ()	9.1
4 ()	9.8
4 ()	9.8
7 ()	28.7
74 ()	7.4
2 ()	9.7

V4-B6 • 19-21 • 24-26

BCME	0.44 ()	
CFORM		0.43 ()
t-1,2-DCE		0.41 ()

V4-B3 • 14-16 • 19-21

BZ	0.049 ()	0.062 ()
CFORM	0.31 ()	0.52 ()
1,2-DBZ	0.69 ()	0.90 ()
1,3-DBZ		0.85 ()
1,4-DBZ		0.85 ()
XYLENES	0.69	2.6
TOL		1.7 ()

ASPHALT
PARKING LOT

V4-BG1

V4-BG1 09-11 14-16/D • 19-21

BZ	0.059 ()	0.13 ()	0.11 ()
BFORM	0.10 ()		
1,2-DBZ		0.3 ()	
1,3-DBZ		0.21 ()	
1,4-DBZ		0.34 ()	
1,1-DCE			0.20 ()
1,2-DMBZ		0.31 ()	
1,3-DMBZ		0.37 ()	
1,4-DMBZ		0.37 ()	
XYLENES		1.05	
EBZ		0.27 ()	
TOL		0.23 ()	
1,2,3-TCP		0.056 ()	

ASPHALT

ROAD

EARTH TECH

INSTALLATION RESTORATION PROGRAM
158TH FIGHTER WING
SOUTH BURLINGTON, VERMONT

SITES 3 AND 4
LABORATORY DETECTIONS OF VOLATILE ORGANIC
COMPOUNDS IN SUBSURFACE SOIL SAMPLES

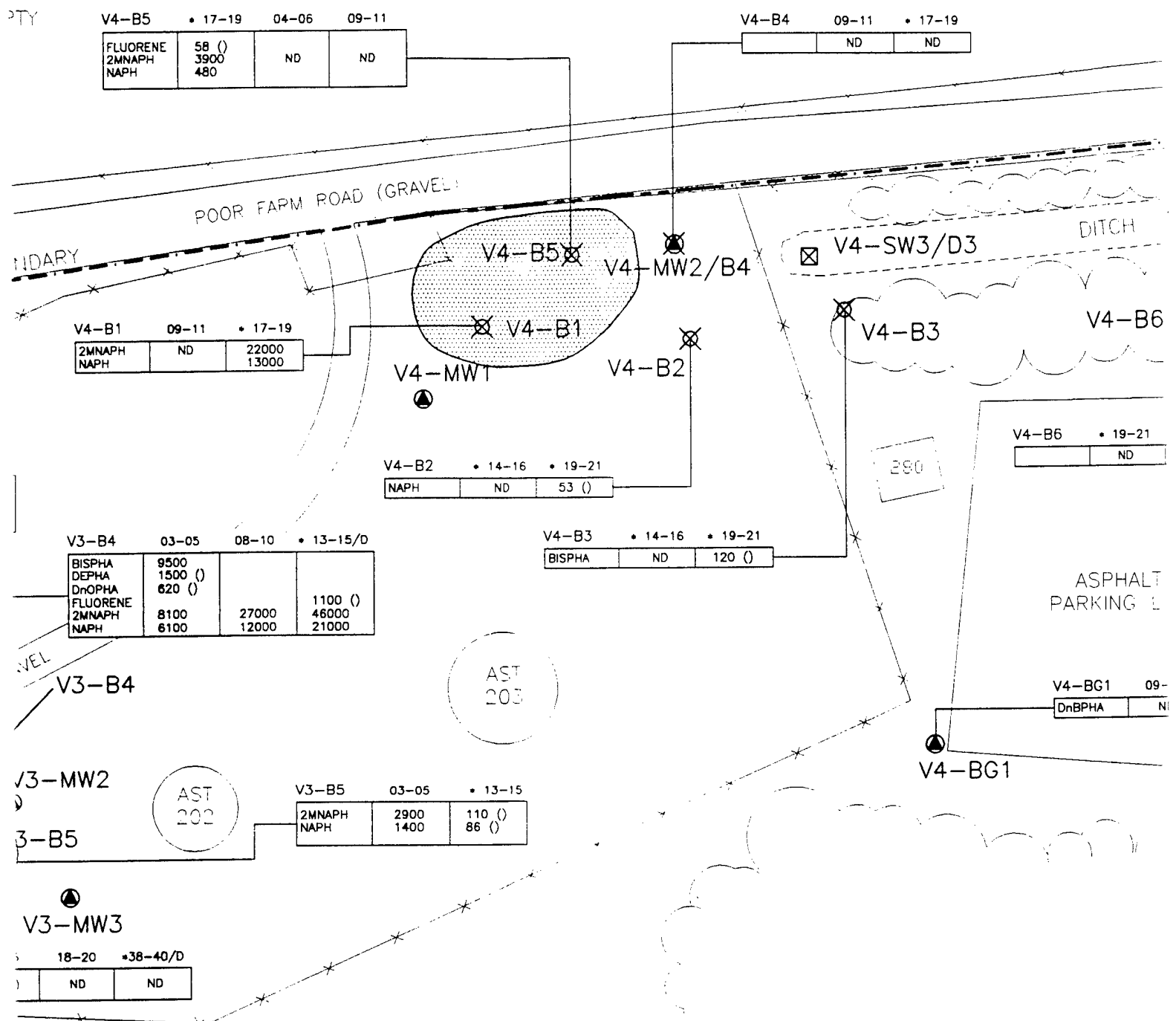
APPROXIMATE AREA OF SOIL CONTAMINATION;
VOLATILE ORGANIC COMPOUNDS IN EXCESS
OF 1992 STATE OF VERMONT RESIDUAL
SOIL VALUES

SCALE

0 60 FEET

FIGURE 5-11

PTY



MONITORING WELL LOCATION

NO ENTRY INDICATES NO DETECTION

SOIL BORING LOCATION

MONITORING WELL/SOIL BORING LOCATION

03-05/D

SAMPLE DEPTH INTERVAL IN FEET

D INDICATES DUPLICATE SAMPLE ALSO ANALYZED (HIGHEST OF THE TWO RESULTS ARE PRESENTED)

INDICATES SAMPLE LOCATED AT OR NEAR THE WATER TABLE (WITHIN 5 FEET)

NO DETECTION

RESULT IS BELOW SAMPLE-SPECIFIC CONTRACT REQUIRED QUANTITATION LIMIT

BISPHA

DEPHA

DnBPHA

DnOPHA

2MNAPH

NAPH

BIS(2-ETHYLHEXYL)PHthalate

DIETHYLPHthalate

DI-N-BUTYLPHthalate

DI-N-OCTYLPHthalate

2-METHYLNAPHTHALENE

NAPHTHALENE

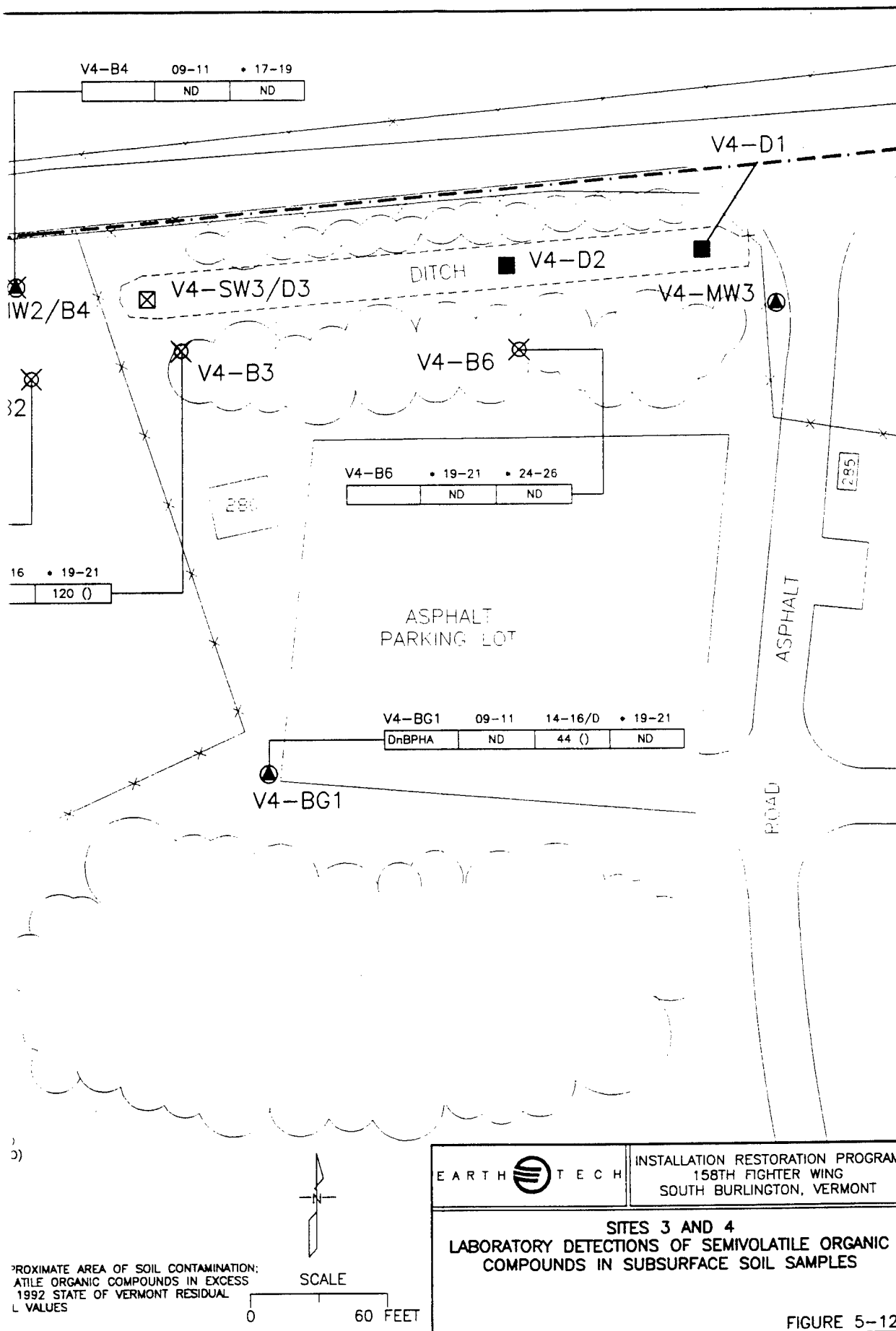
APPROXIMATE AREA OF SOIL CONTAMINATION: VOLATILE ORGANIC COMPOUNDS IN EXCESS OF 1992 STATE OF VERMONT RESIDUAL SOIL VALUES

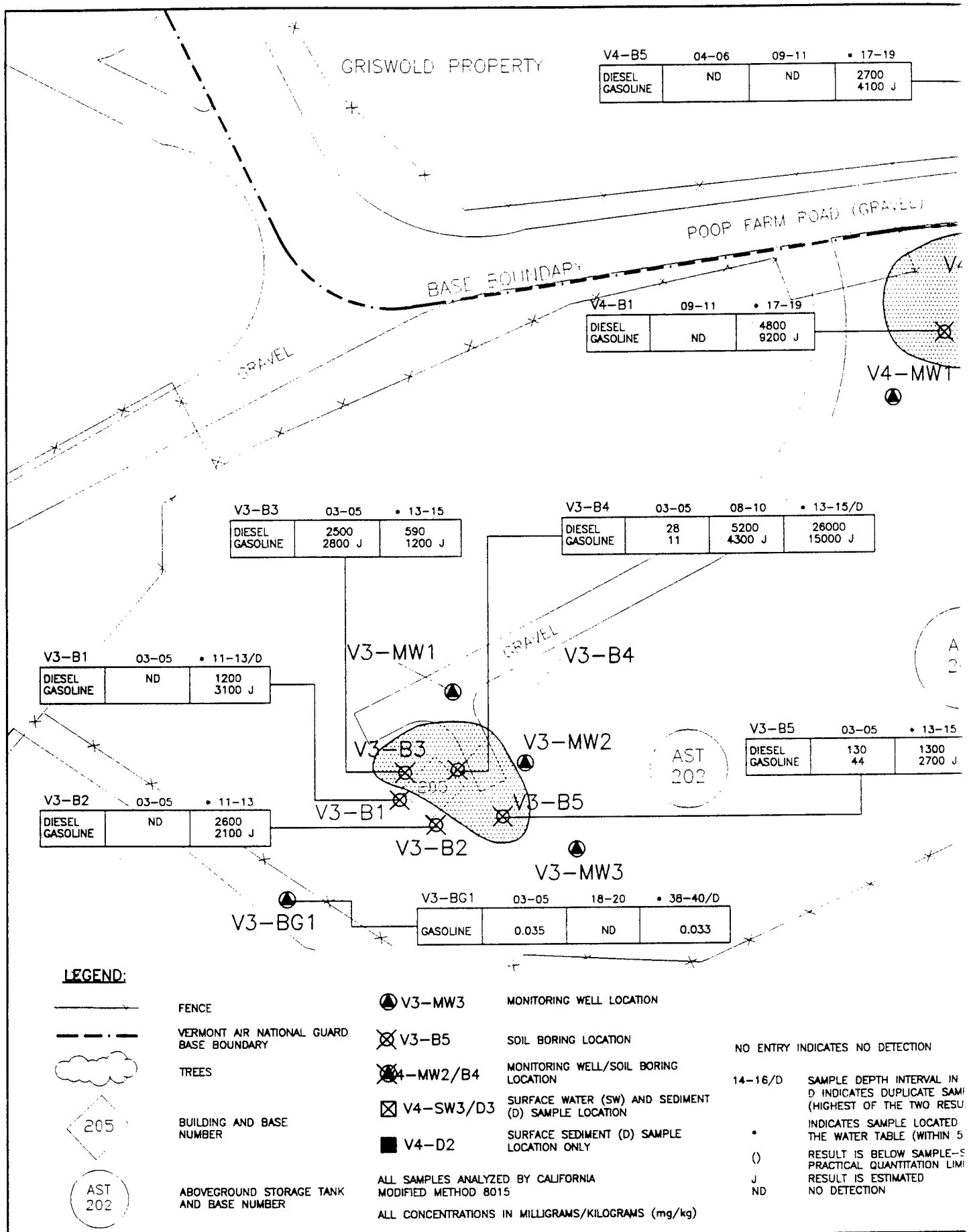
SCALE

0 60 FEET

EARTH

LABOR CC





B5	04-06	09-11	• 17-19
L	ND	ND	2700
LINE			4100 J

V4-B4	09-11	• 17-19
GASOLINE	ND	2500

09-11	• 17-19
ND	4800
	9200 J

03-05	08-10	• 13-15/D
28	5200	26000
11	4300 J	15000 J

V4-B2	14-16	• 19-21
GASOLINE	ND	2.1

V4-B3	• 14-16	• 19-21
	ND	ND

V4-B6	• 19-21
	ND

V3-B5	03-05	• 13-15
DIESEL	130	1300
GASOLINE	44	2700 J

V4-BG1	09-11	14-16/D	• 19-21
	ND	ND	ND

• 38-40/D
0.033

NO ENTRY INDICATES NO DETECTION

BORING 14-16/D SAMPLE DEPTH INTERVAL IN FEET
D INDICATES DUPLICATE SAMPLE ALSO ANALYZED
(HIGHEST OF THE TWO RESULTS ARE PRESENTED)

SEDIMENT

SAMPLE • INDICATES SAMPLE LOCATED AT OR NEAR
THE WATER TABLE (WITHIN 5 FEET)

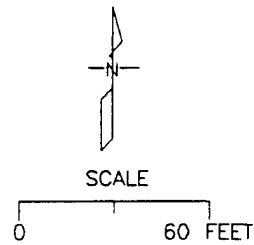
() RESULT IS BELOW SAMPLE-SPECIFIC
PRACTICAL QUANTITATION LIMIT

J RESULT IS ESTIMATED

ND NO DETECTION

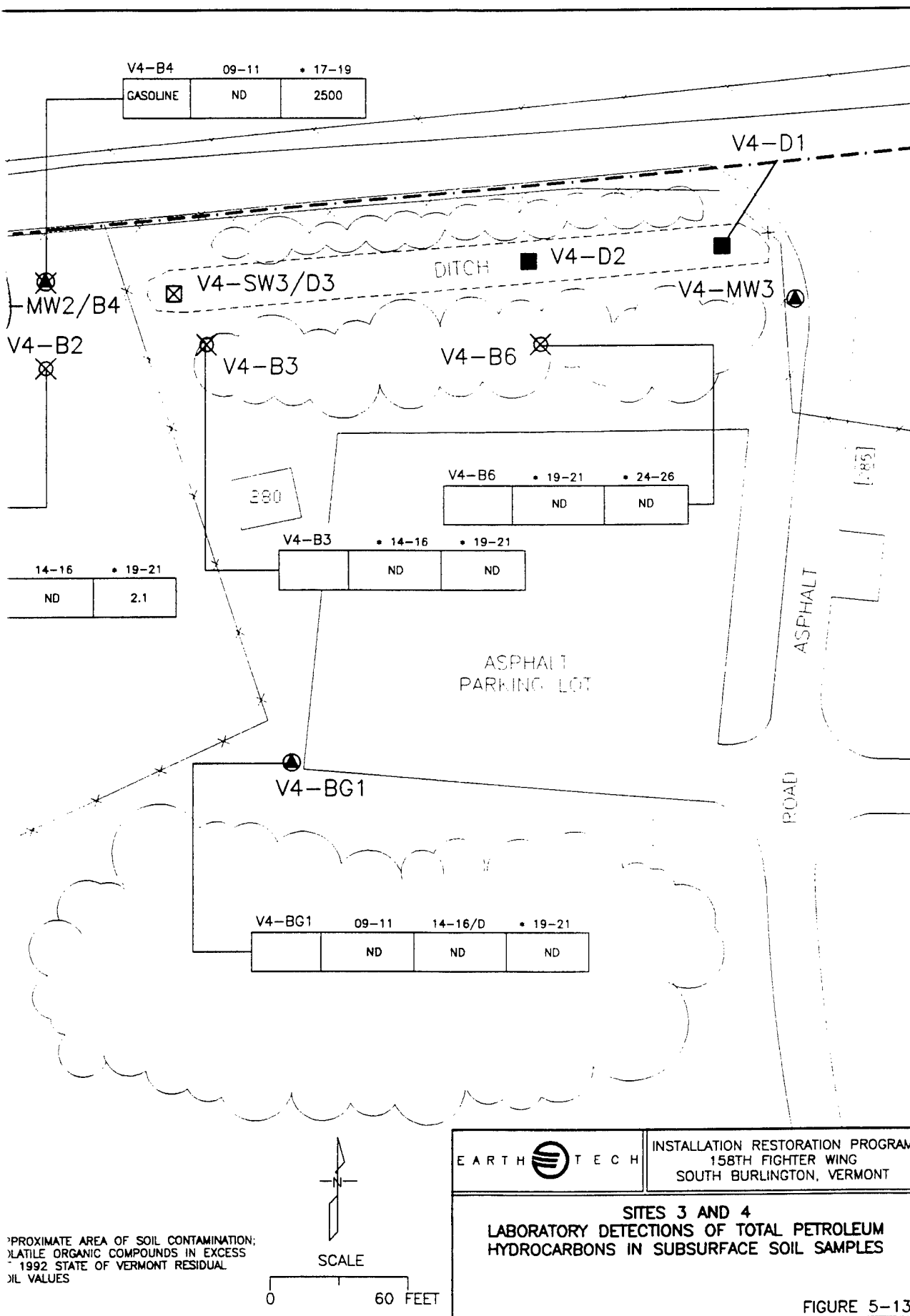
(mg/kg)

APPROXIMATE AREA OF SOIL CONTAMINATION:
VOLATILE ORGANIC COMPOUNDS IN EXCESS
OF 1992 STATE OF VERMONT RESIDUAL
SOIL VALUES



EARTH TECH

SR
LABORATORY DETEC
HYDROCARBONS IN



detections in excess of Residual Soil Values in Site 3 soils were indicated in boring V3-B4, located adjacent to the northeast wall of Building 205. High detections there were indicated in the intermediate sample intervals (8 to 10 ft and 13 to 15 ft bgs), particularly in the 13 to 15 ft sample, in which detections exceeded all the aforementioned soil guidance values, and included 3,700 ppb benzene, 18,000 ppb chlorobenzene, 30,000 ppb 1,2-dichlorobenzene, 20,000 1,3-dichlorobenzene, 13,000 ppb 1,4-dichlorobenzene, 140,000 ethylbenzene, 40,000 styrene, 180,000 ppb toluene, and 570,000 ppb total xylenes.

Detections of VOCs in soil samples from Site 4 background boring V4-BG1 were limited to low concentrations (less than 1 ppb and PQLs) of benzene, bromoform, 1,2-, 1,3-, and 1,4-dichlorobenzenes, 1,1-DCE, 1,2-, 1,3-, and 1,4-dimethylbenzenes, ethylbenzene, toluene, and 1,2,3-trichloropropane. Most detections were indicated in the intermediate sample interval (14 to 16 ft bgs).

Detections of VOCs in soil samples from Site 4 borings ranged from low to high concentrations, some in excess of the State of Vermont Residual Soil Values. Most borings (V4-B2, V4-B3, V4-B4, and V4-B6) indicated no significant detections (generally less than PQLs or at the most less than 100 ppb). The highest detections of VOCs (in excess of 1,000 ppb and Residual Soil Values) in Site 4 soils were indicated in borings V4-B1 and V4-B5, from sample depths located adjacent to the water table (17 to 19 ft bgs). These borings are located in the western end of Site 4, in the vicinity of the sewer line excavation which initially identified soil contamination at the site. In these borings, detections of VOCs exceeded all of the following Residual Soil Values chlorobenzene (2,000 ppb), 1,2-dichlorobenzene (12,400 ppb), 1,4-dichlorobenzene (1,500 ppb), ethylbenzene (13,600 ppb), styrene (100 ppb), and total xylenes (dimethylbenzenes) (8,000 ppb). Detections exceeding Residual Soil Values in boring V4-B1 included 15,000 ppb chlorobenzene, 21,000 ppb 1,2-dichlorobenzene, 3,100 ppb 1,4-dichlorobenzene, 50,000 ppb ethylbenzene, 32,000 ppb styrene, and 120,000 total xylenes. Detections exceeding Residual Soil Values in boring V4-B5 included 8,000 ppb chlorobenzene, 22,000 ppb 1,2-dichlorobenzene, 31,000 1,4-dichlorobenzene, 26,000 ethylbenzene, 7,500 ppb styrene, and 95,000 ppb total xylenes.

SVOCs

Laboratory analyses for SVOCs in subsurface soil samples were conducted according to CLP Methods, 3/90 Revision (EPA 1990a). Detections of SVOCs in subsurface soil samples, reported in concentrations of $\mu\text{g/kg}$ or ppb, are summarized in Table 5-2 and Figure 5-12. State of Vermont Residual Soil Values for SVOCs are available for only a limited number of analytes. No guidance values are available for detections of SVOCs in Sites 3 and 4.

Detections of SVOCs in soil samples from Site 3 background boring V3-BG1 were limited to low concentration (below the CRQL) of diethylphthalate (130 () ppb) in the shallow sample interval (3 to 5 ft bgs). Detections of SVOCs in soil samples from Site 3 borings ranged from low (below CRQLs) to higher (above CRQLs) concentrations. Low concentrations (below CRQLs) diethylphthalate, di-n-octylphthalate, fluorene, 2-methylnaphthalene, and naphthalene, were indicated shallow (3 to 5 ft bgs) and/or intermediate (11 to 13 and 13 to 15 ft bgs) sample intervals in borings V3-B1, V3-B3, V3-B4, and V3-B5. Higher detections (above CRQLs) were limited to concentrations of 2-methylnaphthalene (910 to 46,000 ppb) and naphthalene (340 to 21,000 ppb) in samples from borings V3-B1, V3-B2, V3-B4, and V3-B5;

and one concentration of bis(2-ethylhexyl)phthalate (9,500 ppb) in boring V3-B4. These detections were indicated in shallow (3 to 5 ft bgs) and/or intermediate (8 to 10, 11 to 13, and 13 to 15 ft bgs) sample intervals. The highest detections of 2-methylnaphthalene (46,000 ppb) and naphthalene (21,000 ppb) were indicated in the intermediate (8 to 10 and 13 to 15 ft bgs) sample intervals in boring V3-B4, which similarly indicated the highest detections of VOCs. The next highest detections of 2-methylnaphthalene (11,000 ppb) and naphthalene (5,400 ppb) were indicated in the intermediate sample (11 to 13 ft bgs) from boring V3-B1.

Detection of SVOCs in soil samples from Site 4 background boring V4-BG1 was limited to a low concentration (below the CRQL) of di-n-butylphthalate (44 () ppb). Detections of SVOCs in soil samples from Site 4 borings ranged from low to high concentrations. No detections were indicated in all intermediate (9 to 11 and 19 to 21 ft bgs) and water table (17 to 19 and 24 to 26 ft bgs) sample intervals from borings V4-B4 and V4-B6. Similarly, only low concentrations (below CRQLs) were indicated in the two water table samples (19 to 21 ft bgs) from borings V4-B2 (53 () ppb naphthalene) and V4-B3 (120 () ppb bis(2-ethylhexyl)phthalate). Higher detections (above CRQLs) were limited to concentrations of 2-methylnaphthalene (3,900 to 22,000 ppb) and naphthalene (480 to 13,000 ppb) in water table samples (19 to 21 ft bgs) from borings V4-B1 and V4-B5. The highest detections were indicated in the sample from boring V4-B5. These locations correspond with the locations of significant detections of VOCs.

TPH

Laboratory analyses for TPH in subsurface soil samples were conducted according to California Modified Method 8015 (California 1988). Detections of TPH (diesel and gasoline) in subsurface soil samples, reported in concentrations of mg/kg or ppm, are summarized in Table 5-2 and Figure 5-13.

Detections of TPH in soil samples from Site 3 background boring V3-BG1 were limited to a low concentrations (below 1 ppm) of gasoline (0.035 and 0.033 ppm) in the shallow (3 to 5 ft bgs) and water table (38 to 40 ft bgs) samples. No detections for diesel were indicated.

Detections of TPH (diesel and gasoline) in soil samples from Site 3 borings ranged from low to high concentrations. No detections of diesel were indicated in the two shallow samples (3 to 5 ft bgs) from borings V3-B1 and V3-B2. Otherwise, detections (10 to 1,000 ppm) of diesel and gasoline were indicated in all other shallow and deeper samples; from borings V3-B1, V3-B2, V3-B3, V3-B4, and V3-B5. Diesel concentrations ranged from 28 ppm in boring V3-B5 (3 to 5 ft bgs) to 26,000 ppm in boring V3-B4 (13 to 15 ft bgs). Gasoline concentrations ranged from 11 ppm (3 to 5 ft bgs) to 15,000 J ppm in boring V3-B4. The intermediate sample interval in boring V3-B4 (13 to 15 ft bgs) indicated the highest site-wide TPH (diesel and gasoline) detections, corresponding to the highest detections of VOCs and SVOCs.

No detections of TPH were indicated in all three soil samples from Site 4 background boring V4-BG1. Sample intervals ranged from intermediate depths (9 to 11 and 14 to 16 ft bgs) to the water table (19 to 21 ft bgs).

Detections of TPH (diesel and gasoline) in soil samples from Site 4 borings ranged from low to high concentrations. No detections were indicated in all four soil samples from borings V4-B3 and V4-B6. Only a low concentration of gasoline (2.1 ppm) was indicated in the water table samples (19 to 21 ft bgs) from boring V4-B2. No detections were also indicated in shallow (4 to 6 ft bgs) and intermediate (9 to 11 ft bgs) samples from borings V4-B1, V4-B4, and V4-B5. Significant detections (in excess of 1,000 ppm) of diesel and gasoline were indicated in water table samples (19 to 21 ft bgs) from borings V4-B1 and V4-B5, and of gasoline only in the water table sample (19 to 21 ft bgs) from boring V4-B4. Diesel concentrations ranged from 2,700 ppm in boring V4-B5 to 4,800 ppm in boring V4-B1. Gasoline concentrations ranged from 2,500 ppm in boring V4-B4 to 4,100 J ppm in boring V4-B5 and to 9200 J ppm in boring V4-B1. Borings V4-B1 and V4-B5 indicated the highest TPH detections, as well as the highest VOC and SVOC detections.

5.2.3.2 Inorganics - Subsurface Soils

Laboratory analyses for TAL metals in subsurface soil samples were conducted according to EPA CLP Methods, 3/90 Revision (EPA 1990b). Inorganics in subsurface soil samples from Sites 3 and 4 (including background locations) are summarized in the following discussion of laboratory analytical detections of TAL metals.

Base-wide background values for TAL metals in soils were determined from a statistical evaluation of detections in 14 surface and subsurface soil samples from SRI and ASI background borings in IRP Sites 1 and 2; boring V1-BR4 (3 samples) in Site 1 and boring V2-BG1 (5 samples) in Site 2; and in IRP Sites 3 and 4; boring V3-BG1 (3 samples) in Site 3 and V4-BG1 (3 samples) in Site 4. SRI (Sites 1 and 2) and ASI (Sites 3 and 4) field investigations were conducted concurrently. Approximate locations of base-wide background borings are presented on Figure 1-2. Samples with corresponding duplicate samples were averaged separately to generate one value for each sample interval. It is estimated that the background locations, being hydraulically up-gradient of suspected source areas, best reflect average base-wide concentrations of metals in soils. Generally, background and site area analytical detections for TAL metals are comparable, however, some variations are indicated. Analytical detections and resulting mean concentrations were used to calculate standard deviations. Based on the recommendation of the Vermont HMMD (Telecon 1995b), guidance background values, representing a 95% confidence level, were determined (when sufficient data were available) using two standard deviations above each mean concentration. The statistical equations used to calculate the mean concentration, standard deviation, and guidance background value for each TAL metal are as follows:

Mean Concentration -

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

Standard deviation -

$$s = \left[\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2 \right]^{1/2}$$

Guidance background value

$$x_{background} = \bar{x} + 2s$$

where x = analyte concentration, n = number of samples, and s = standard deviation.

Aside from the background value calculations presented above, background concentrations were also determined according to the following criteria:

- if the calculated background value exceeded the maximum analyte detection, the maximum analyte detection was used as the background value,
- if no background analyte detections were indicated, the background value was equal to one-half of the analyte CRDL (the average of sample-specific CRDLs for soils),
- if only one background analyte detection was indicated and other background analyte detections were not useable due to R or B data qualifiers, the background value was equal to the one usable detection.

No detections above CRDLs were indicated for six of the 23 TAL metals in all background soil samples; antimony, cadmium, mercury, silver, selenium, and thallium. It should be noted that source area concentrations in excess of background values are not necessarily anomalous, particularly considering the probable effects of local geologic conditions. The base-wide background values, calculated from analytical results from only four locations, are best utilized as general reference values to aid in identifying possibly anomalous concentrations. It should also be noted that many background sample detections were less than CRDLs (detections qualified with ()), and therefore are considered estimated low concentrations.

Base-wide background values for all 23 TAL metals in subsurface soils from Sites 3 and 4 are presented in Table 5-3. Analytical detections of TAL metals in subsurface soil samples from ASI background and source area borings are presented in Table 5-4. Site area TAL metal concentrations equal to or in excess of background values are highlighted on Table 5-4. Table 5-4 also presents applicable background values. Figure 5-14 presents all highlighted detections of TAL metals (those equal to or in excess of background values) in Site 3 and Site 4 area soils from Table 5-4. TAL metal detections in soils are reported in mg/kg or ppm. Site area TAL metals detections equal to or in excess of background values are presented in the following discussion. State of Vermont Residual Soil Values are not available for TAL metals concentrations (Vermont 1992a). Complete listings of all ASI analytes and laboratory analytical results are presented in Appendix J. Complete listings of SRI and ASI analytical results for inorganics in soil samples from background borings in IRP Sites 1 through 4 are presented in Appendix K.

Detections of TAL metals above background values in soil samples from Site 3 borings ranged from low (below CRDLs) to higher concentrations (above CRDLs). In borings V3-B1 and V3-B2, low detections (below CRDLs) consisted of beryllium (0.23 () to 0.24 () ppm), cobalt (9.6 () to 9.9 () ppm), and potassium (615 J () to 646 J () ppm) in intermediate sample intervals (11 to 13 ft bgs). Higher detections (above CRDLs) in these borings consisted of aluminum (7070 to 7580 ppm), and vanadium (14.4 to 14.9 ppm), primarily in the intermediate sample intervals. Borings V3-B3, V3-B4, and V3-B5 indicated similarly low concentrations of barium and beryllium, in shallow and/or deeper samples. Higher detections in borings V3-B3, V3-B4, and V3-B5 (above CRDLs) in shallow (3 to 5 ft bgs) and/or intermediate (8 to 10 and 13 to 15 ft bgs) samples included aluminum (7,420 to 10,200 ppm), barium (47.4 to 49.5 ppm), iron (19,800 ppm), nickel (26.4 to 30.7 ppm), vanadium (13.5 to 17.3 ppm) and zinc (47.9

**Table 5-3 Base-Wide Background Values for Inorganic Analytes in Soil Samples
Vermont Air National Guard Base**

TAL Metals ¹ (mg/kg)	Background Mean ^(a)	Background Value ^(b)
Aluminum	4450	6870 ⁽¹⁾
Antimony	ND	7.0 ⁽²⁾
Arsenic	4.48	8.54
Barium	14.6	44.9
Beryllium	0.079	0.16
Cadmium	ND	0.56 ⁽²⁾
Calcium	2750	11750
Chromium	9.94	16.1
Cobalt	6.32	9.32
Copper	12.8	18.9
Iron	11300	15850 ⁽¹⁾
Lead	4.97	11.8
Magnesium	3250	8390
Manganese	282	479
Mercury	ND	0.065 ⁽²⁾
Nickel	16.3	24.7
Potassium	326	458 ⁽¹⁾
Selenium	ND	0.49 ⁽²⁾
Silver	ND	0.49 ⁽²⁾
Sodium	192	304 ⁽¹⁾
Thallium	ND	0.45 ⁽²⁾
Vanadium	9.79	13.2 ⁽¹⁾
Zinc	27.2	45.4

¹ TAL Metals - Target Analyte List metals - analyzed by U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3/90). All concentrations in milligrams/kilogram (mg/kg) or parts per million (ppm).

^(a) Background Mean calculated from base-wide background vadose zone (upper overburden) soil analytical results from Site 1 boring V1-BR4, Site 2 boring V2-BG1, Site 3 boring V3-BG1, and Site 4 boring V4-BG1.

^(b) Background Value is equal to the Background Mean plus two Standard Deviations, or as indicated below.

⁽¹⁾ If Background Mean plus two Standard Deviations is greater than Maximum Background Detection, then Background Value = Maximum Background Detection.

⁽²⁾ If TAL metal was not detected in background samples, then Background Concentration = $\frac{1}{2}$ (average sample-specific Contract Required Detection Limit).

ND Analyte not detected in background soil samples.

Table 5-4 Laboratory Detections of Inorganic Analytes in Subsurface Soil Samples
Vermont Air National Guard Base

Area Location			Site Background						Site 3			
Sample Location			V3-BG1			V3-B1			V3-B2			
Sample Depth (ft bgs)	Date Sampled	Material Type	03-05 Silty Sand	18-20 9/20/94 Sand/Silt	*38-40 9/20/94 Sand/Silt	*38-40 D	03-05 10/25/94 Silty Sand	*11-13 9/30/94 Sand/Silt	*11-13 D	03-05 10/25/94 Silty Sand	*11-13 9/30/94 Sand/Silt	
Moisture Content %			12.0	3.2	19.3	24.3	8.1	11.9	16.3	8.8	13.9	
TAL' Metals (mg/kg) (a)	Background ^b	CRDL										
Aluminum	6870	40	5950	2270	6660	6980	7070	5570	7580	7530	7190	
Antimony	7	12										
Arsenic	8.54	2	5.6	3.6	2.7	3.0	4.0	3.2	3.6	4.3	3.8	
Barium	44.9	40	14.2 ()	5.2 J ()	15.3 ()	16.5 ()	15.8 ()	15.9 ()	20.4 ()	15.3 ()	21.2 ()	
Beryllium	0.16	1						0.17 ()	0.24 ()		0.23 ()	
Calcium	11750	1000	1410	1470	2610	2840	735 ()	1640	1840	634 ()	1740	
Chromium	16.1	2	18.2	5.9 J	14.4	14.8	13.5	9.8	13.0	14.1	12.6	
Cobalt	9.32	10							9.9 ()		9.6 ()	
Copper	18.9	5	11.2	9.9 J	16.3	17.3	8.3	17.4	17.2	7.6	15.3	
Iron	15850	20	13600	7010	15500	16200	13300	11700	15400	13900	14600	
Lead	11.8	0.6	5.5	2.3	4.6 J	4.9 J		4.5	5.1	5.4 J	5.0	
Magnesium	8390	1000	3540	1720	4000	4190	2670	2830	4000	2740	3770	
Manganese	479	3	328	201	367	391	145	160	206	142	194	
Nickel	24.7	8	23.4	12.4 J	21.5	28.3	17.5	17.3	20.1	18.3	19.8	
Potassium	458	1000		237 J ()				453 J ()	646 J ()		615 J ()	
Sodium	304	1000	119 ()	153 J ()	294 ()	314 ()	100 ()			114 ()		
Vanadium	13.2	10	11.2 ()	5.9 ()	13.4	13.1 ()	13.0	10.8 ()	14.9	11.6	14.4	
Zinc	45.4	4	26.7	16.1 J	35.5	37.3	26.5	33.6	38.2	30.7	36.7	
TAL' Metals Dilution Factor			1	1	1	1	1	1	1	1	1	

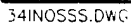
Table 5-4 Laboratory Detections of Inorganic Analytes in Subsurface Soil Samples
Vermont Air National Guard Base

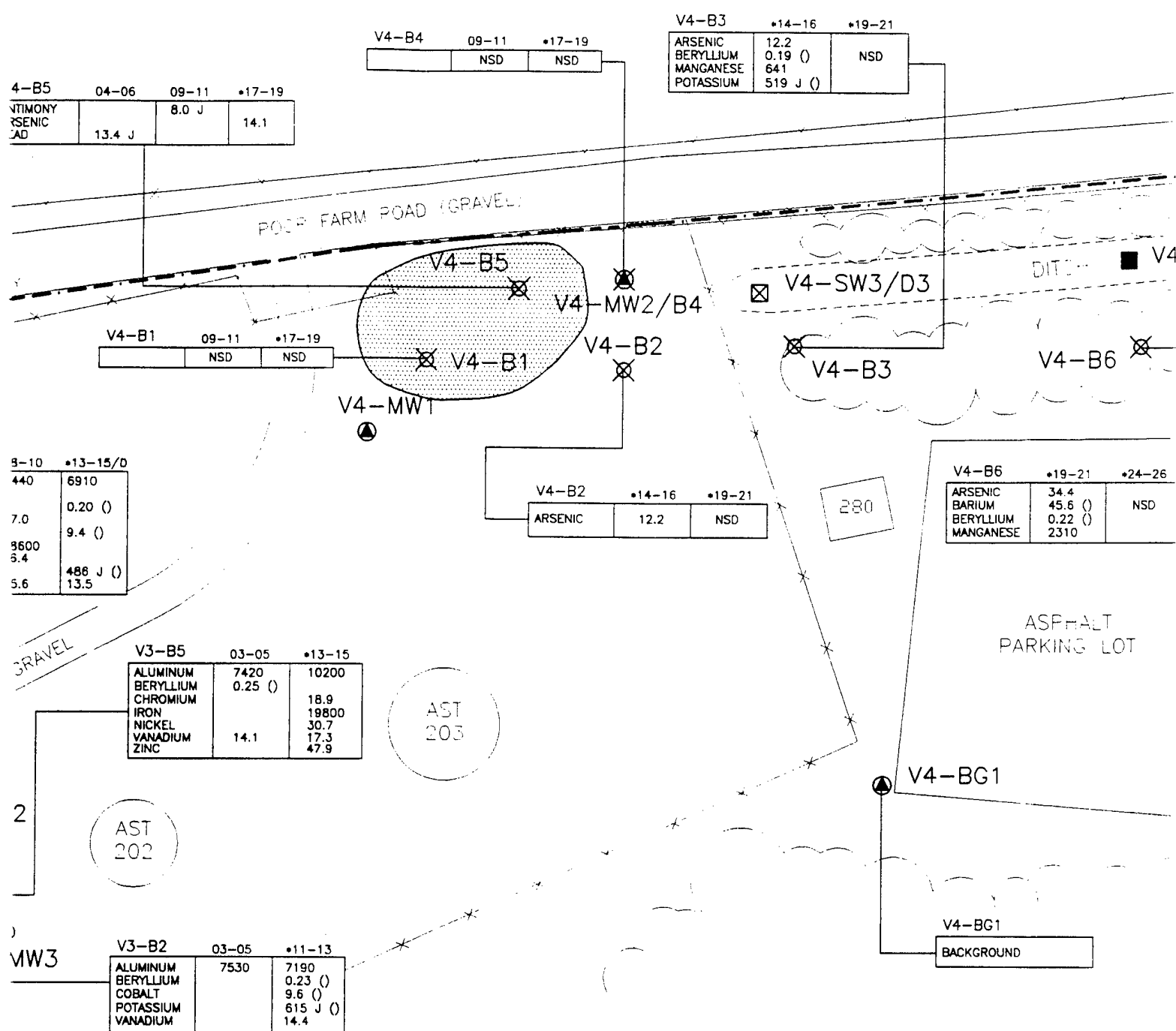
Area Location			Site 3										Site 4 Background			
Sample Location			V3-B3			V3-B4				V3-B5			V4-BG1			
Sample Depth (ft bgs)	Date Sampled	Material Type	03-05 9/13/94 Silty Sand	*13-15 9/13/94 Sand/Silt	03-05 9/13/94 Silty Sand	08-10 9/13/94 Sand/Silt	*13-15 9/13/94 Silty Sand	*13-15 D 9/13/94 Silty Sand	03-05 9/13/94 Silty Sand	*13-15 9/13/94 Silt/Sand	09-11 9/10/94 Sand/Silt	14-16 9/10/94 Sand/Silt	14-16 D	*19-21 9/10/94 Silty Sand		
Moisture Content %			12.7	11.6	12.2	7.0	9	17.9	9	20.5	3.8	2.8	7.8	20.2		
TAL ¹ Metals (mg/kg) (a)	Background ²	CRDL														
Aluminum	6870	40	10200	5200	8680	9440	4310	6910	7420	10200	3540	3790	5280	4140		
Antimony	7	12														
Arsenic	8.54	2	3.1	2.7	2.6	3.8	3.4	3.2	2.3	4.9	3.1	8.9	9.6	3.5		
Barium	44.9	1	47.4	14.7 ()	49.5	27.9 ()	10.6 ()	16.4 ()	29.1 ()	30.4 ()	9.6 ()	13.0 ()	13.6 ()	9.0 ()		
Beryllium	0.16	1					0.18 ()	0.20 ()	0.25 ()		0.17 ()		0.13 ()			
Calcium	11750	1000	841 ()	1820	641 ()	2180	1540	1750	248 ()	2250	1240	1450	1750	1700		
Chromium	16.1	2	13.7	9.1	9.2	17.0	9.6	12.2	11.2	18.9	7.7	6.9	10.6	8.3		
Cobalt	9.32	10					7.6 ()	9.4 ()	7.4 ()		7.4 ()	8.5 ()	10.7 ()	8.1 ()		
Copper	18.9	5	5.4 ()	13.2	5.0 ()	17.6	12.5	16.2	8.4	18.3	11.7	14.9	15.3	13.9		
Iron	15850	20	13300	11900	12200	18600	10300	14400	11900	19800	7700	13200	16500	10500		
Lead	11.8	0.6	8.0 J	3.7 J	5.9 J	5.2 J	3.2	5.0	5.4	5.8 J	4.1	3.6	4.0	3.8		
Magnesium	8390	1000	1900	2760	2310	4790	2390	3640	1980	5160	1930	1950	2870	2520		
Manganese	479	3	217	147	257	417	153	197	437	336	255	580	548	263		
Nickel	24.7	8	13.8	21.3	18.6	28.4	15.8	23.6	12.1	30.7	15.1	18.7	21.2	16.2		
Potassium	458	1000					355 J ()	486 J ()	300 J ()		363 J ()	392 J ()	524 J ()	434 J ()		
Sodium	304	1000	119 ()	127 ()	109 ()	125 ()				160 ()						
Vanadium	13.2	10	17.0	10.2 ()	12.2	15.6	10.1 ()	13.5	14.1	17.3	6.8 ()	9.6 ()	13.4	10.1 ()		
Zinc	45.4	4	34.5	27.0	31.3	43.2	25.2	35.9	30.1	47.9	18.3	26.4	31.8	26.7		
TAL ¹ Metals Dilution Factor			1	1	1	1	1	1	1	1	1	1	1	1		

Table 5-4 Laboratory Detections of Inorganic Analytes in Subsurface Soil Samples
Vermont Air National Guard Base

Area Location		Site 4												
Sample Location		V4-B1			V4-B2		V4-B3		V4-B4		V4-B5		V4-B6	
Sample Depth (ft bgs)	Date Sampled	09-11 9/8/94 Sand/Silt	*17-19 9/8/94 Sand	*14-16 9/7/94 Sand	*19-21 9/7/94 Sand/Silt	*14-16 9/30/94 Silty Sand	*19-21 9/30/94 Sand	09-11 9/30/94 Silty Sand	9/30/94 Sand	04-06 10/25/94 Silty Sand	09-11 10/25/94 Silty Sand	*17-19 10/25/94 Silty Sand	*19-21 9/30/94 Sand	*24-26 9/30/94 Sand/Silt
Moisture Content %		17.2	13.2	4.1	21.3	5.2	21.0	20.2	6.1	9.4	19.7	15.7	15.8	20.0
TAL ¹ Metals (mg/kg) (a)														
Aluminum	Background ² 40	4320	2400	3710	3380	3780	4190	4000	3320	6170	7290	5630	3570	2920
Antimony	7										8.0 J			
Arsenic	8.54	6.1	6.1	12.2	5.3	12.2	2.5 ()	4.1	7.4	4.8	3.2	14.1	34.4	3.1
Barium	44.9	10.8 ()	9.3 ()	10.6 ()	12.8 ()	24.5 ()	8.6 ()	10.1 ()	10.9 ()	16.1 ()	16.9 ()	13.3 ()	45.6 ()	6.4 ()
Beryllium	0.16					0.19 ()			0.14 ()				0.22 ()	
Calcium	11750	1760	572 ()	882 ()	1610	3670	1940	1510	793 ()	1370	1550	1020 ()	1120 ()	1730
Chromium	16.1	6.7	5.9	8.5	6.9	8.3	8.3	5.6	6.8	8.9	10.1	11.4	6.8	6.0
Cobalt	9.32	6.2 ()	4.5 ()	5.5 ()	4.8 ()	5.8 ()	7.2 ()	7.4 ()	5.7 ()				7.0 ()	6.2 ()
Copper	18.9	14.6	6.0	7.5	13.6	11.7	13.1	11.6	8.4	9.7	14.1	9.9	11.1	13.4
Iron	15850	9020	6740	11500	8320	10800	11200	8330	8830	12600	13900	13000	13500	7660
Lead	11.8	4.9	3.2	4.9	4.1	4.4	4.2	5.5	3.6	13.4 J	4.3 J	5.3 J	6.0	4.1
Magnesium	8390	1850	1440	2140	1850	2090	2340	1840	1920	2840	3410	3320	2200	1710
Manganese	479	93.8	441	101	111	641	143	242	101	290	403	149	2310	215
Nickel	24.7	12.9	10.7	15.4	14.4	14.8	16.4	13.8	12.4	21.6	17.9	19.0	17.0	15.7
Potassium	458	445 J ()	296 J ()	285 J ()	336 J ()	519 J ()	398 J ()	386 J ()	391 J ()				454 J ()	327 J ()
Sodium	304									112 ()	197 ()	239 ()		
Vanadium	13.2	8.5 ()	5.4 ()	8.9 ()	7.7 ()	8.0 ()	10.1 ()	7.7 ()	7.0 ()	9.5 ()	11.3 ()	8.3 ()	9.8 ()	6.8 ()
Zinc	45.4	37.1	19.0	21.0	21.9	26.7	25.9	21.3	25.1	37.7	34.2	27.2	26.8	19.0
TAL ¹ Metals Dilution Factor		1	1	1	1	1	1	1	1	1	1	1	1	1

Sample Depth: ft - feet, bgs - below ground surface, D - Duplicate Sample, and * indicates sample located at or near the water table (within 5 feet).
¹ TAL - Target Analyte List Metals - analyzed by U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3190). All concentrations in milligram/kilogram (mg/kg) or parts per million (ppm).
² Background value.
 (a) No entry indicates no detection.
 CRDL - Contract Required Quantitation Limit Values for CRDL represent only low soil matrix. Use the following equation to calculate the CRDL for each individual sample: $CRDL = (Dilution\ factor / (100 \cdot \% moisture / 100))$
 Shaded square containing number represents value above background value.
 () Result is below the sample - specific CRDL.
 J Result value is estimated.

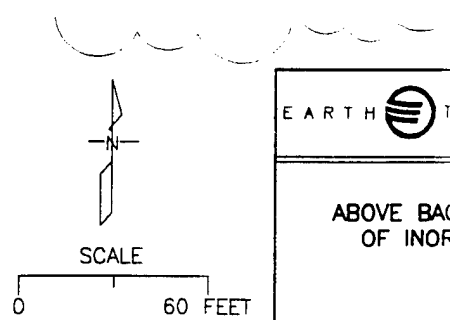


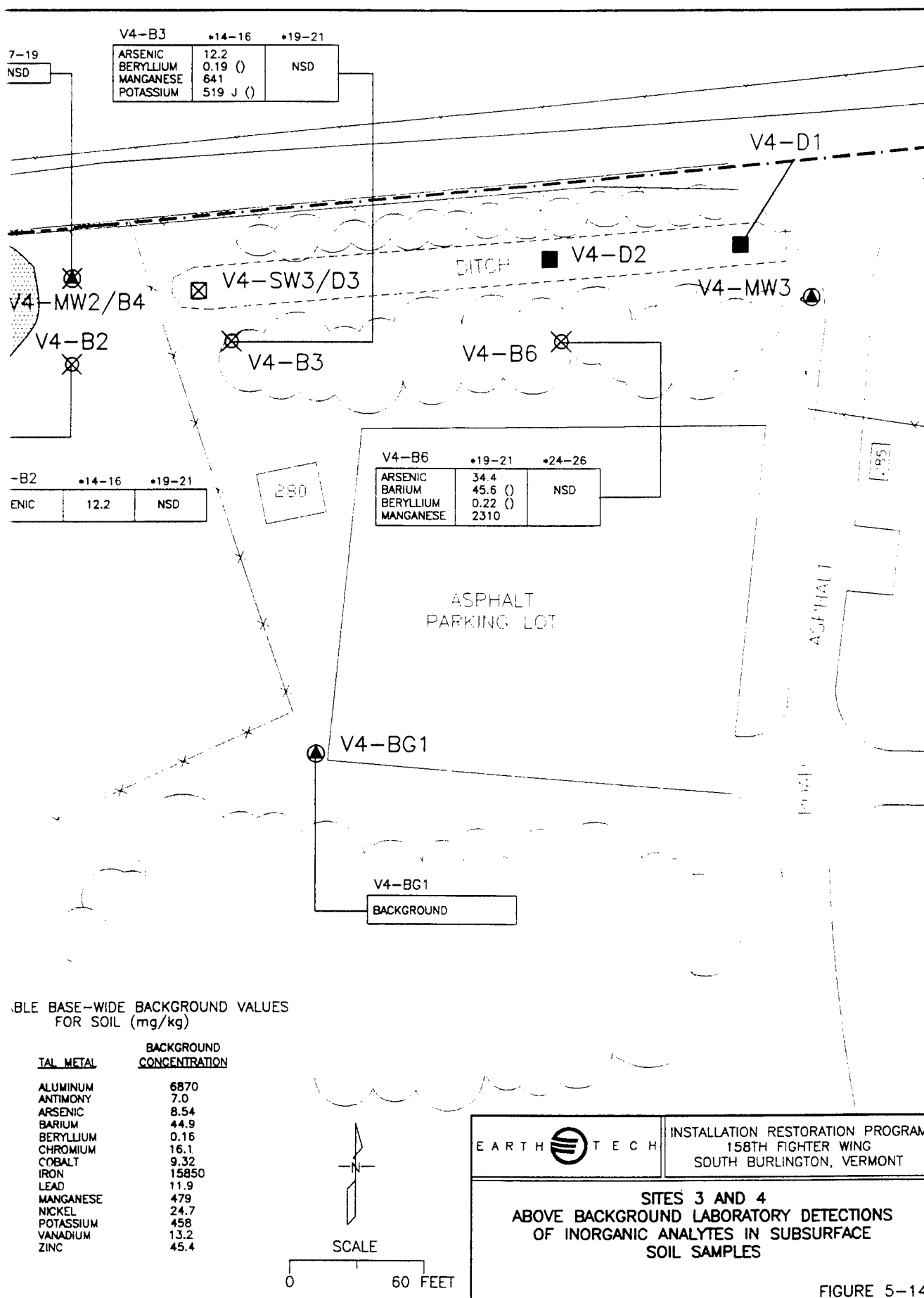


APPLICABLE BASE-WIDE BACKGROUND VALUES
FOR SOIL (mg/kg)

WELL LOCATION	NO ENTRY INDICATES NO SIGNIFICANT DETECTION IN EXCESS OF THE BACKGROUND CONCENTRATION.
LOCATION	
WELL/SOIL BORING	•13-15/D SAMPLE DEPTH INTERVAL IN FEET D INDICATES DUPLICATE SAMPLE ALSO ANALYZED (HIGHEST OF THE TWO RESULTS ARE PRESENTED)
WATER (SW) AND D) SAMPLE LOCATION	• INDICATES SAMPLE LOCATED AT OR NEAR THE WATER TABLE (WITHIN 5 FEET)
WELL/SOIL BORING	NSD NO SIGNIFICANT DETECTION
WELL/SOIL BORING	() RESULT IS BELOW CONTRACT REQUIRED DETECTION LIMIT.
WELL/SOIL BORING	J RESULT IS ESTIMATED
WELL/SOIL BORING	APPROXIMATE AREA OF SOIL CONTAMINATION; VOLATILE ORGANIC COMPOUNDS IN EXCESS OF 1992 STATE OF VERMONT RESIDUAL SOIL VALUES

TOTAL METAL	BACKGROUND CONCENTRATION
ALUMINUM	6870
ANTIMONY	7.0
ARSENIC	8.54
BARIUM	44.9
BERYLLIUM	0.16
CHROMIUM	16.1
COBALT	9.32
IRON	15850
LEAD	11.9
MANGANESE	479
NICKEL	24.7
POTASSIUM	458
VANADIUM	13.2
ZINC	45.4





ppm). The occurrence and concentration of detected TAL metals appear to vary. No site-related anomalous concentrations or trends are apparent.

Detections of TAL metals above background values in soil samples from Site 4 borings ranged from low (below CRDLs) to higher concentrations (above CRDLs). In borings V4-B1 and V4-B4, no concentrations above background were detected. Detections in boring V4-B2 were limited to one detection of arsenic (12.2 ppm) in the intermediate (14 to 16 ft bgs) sample. In borings V4-B3 and V4-B6, low concentrations (below CRDLs) of barium, were indicated in intermediate (14 to 16 and 19 to 21 ft bgs) samples. Higher detections (above CRDLs) in borings V4-B3, V4-B5, and V4-B6 were indicated in shallow (4 to 6 ft bgs) and/or deeper intermediate (9 to 11, 14 to 16, and 19 to 21 ft bgs) and water table samples (17 to 19 ft bgs) samples and included antimony (8 J ppm), arsenic (12.2 to 34.4 ppm), lead (13.4 J ppm), and manganese (641 to 2,310 ppm). The occurrence and concentration of detected TAL metals appear to vary. No site-related anomalous concentrations or trends are apparent, other than the occurrence of arsenic, which was not indicated above the background value in Site 3 soils. Detections of arsenic are only indicated in sample intervals located above or near the water table (from 14 to 21 ft bgs) in borings V4-B2, V4-B3, V4-B5, and V4-B6. The detection of lead (13.4 ppm) in boring V4-B5 (4 to 6 ft bgs) is the only detection above background for both Sites 3 and 4.

5.2.4 Laboratory Analytical Results - Groundwater

One round of groundwater sampling was conducted for the ASI. Excluding QA/QC samples, six groundwater samples (including background locations) were collected from Sites 3 and 4 and submitted for laboratory analysis for VOCs, SVOCs, TPH, and TAL metals (total and dissolved). In Site 3, groundwater samples were collected from two source area monitoring wells (V3-MW1 and V3-MW3) and one hydraulically up-gradient background monitoring well (V3-BG1) (Figure 5-1). In Site 4, groundwater samples were collected from two source area monitoring wells (V4-MW2 and V4-MW3) and one hydraulically up-gradient background monitoring well (V4-BG1) (Figure 5-1). Two monitoring wells were not sampled due to the presence of free-product; well V3-MW2 in Site 3 and well V4-MW1 (Figures 5-1, 5-6, and 5-7). The presence of free-product is discussed further at the end of Section 5.2.4.1.

5.2.4.1 Organics - Groundwater

Organics in groundwater samples from Sites 3 and 4 (including background locations) are summarized in the following discussions of laboratory analytical detections of VOCs, SVOCs, and TPH, and the detection of free-product. When applicable, organic detections are compared to applicable State of Vermont Primary Groundwater Quality Standards; Primary Enforcement Standards (PESs) and Primary Preventative Action Limits (PPALs) (Vermont 1988). State of Vermont Groundwater Quality Standards and May 1995 EPA Drinking Water Standards are presented in Appendix G. Groundwater Quality Standards are available for many VOCs, a limited number of SVOCs, and are not available for TPH.

Detections of VOCs, SVOCs, and TPH per monitoring well are presented in Table 5-5, and in Figure 5-15 (VOCs), Figure 5-16 (SVOCs), and Figure 5-17 (TPH). Detections of organic compounds in excess of the lowest State of Vermont Groundwater Quality Standards (PPALs) are highlighted in the aforementioned table and figures. Applicable ARARs are also presented

Table 5-5 Laboratory Detections of Organic Compounds in Groundwater Samples
Vermont Air National Guard Base

Area Location		Site 3 Background			Site 3		Site 4 Background		Site 4	
Sample Location		V3-BG1	V3-BG1-D	V3-MW1	V3-MW3	V4-BG1	V4-MW2	V4-MW3		
Date Sampled Material Type		10/24/94 Groundwater		10/31/94 Groundwater	10/31/94 Groundwater	10/25/94 Groundwater	10/27/94 Groundwater	10/26/94 Groundwater		
VOCs (µg/l) (a)	ARAR ²	PQL								
Benzene	0.5	0.35		160 ^d			84 ^d			
Chlorobenzene	50	0.25			0.54					
Chloroform		0.35	0.17 ()	0.082		0.15 ()				
1,2-Dichlorobenzene	310	0.15		140	0.90		25 ^d			
1,3-Dichlorobenzene	310	0.20			2.5		6.3 ^d			
1,2-Dimethylbenzene		0.20		2.3	0.73		0.79			
1,3-Dimethylbenzene		0.50		520 ^d			210 ^d			
1,4-Dimethylbenzene		0.50		520 ^d			210 ^d			
Total Xylenes	200			1040			420			
Ethylbenzene	340	0.20		420 ^d	0.55		160 ^d			
Methylene Chloride	2.5	1.0								
Methyl-t-butyl ether		5.0					4.9 ()			
Styrene	0.5	0.25			0.36					
Toluene	1210	0.25	0.47	840 ^d			18 ^d	0.23 ()		
1,1,1-Trichloroethane	100	0.35	0.22 ()	0.18 J ()						
Trichloroethene (TCE)	0.5	0.30	0.15 J ()	0.18 ()	0.24 ()	0.10 ()		0.19 ()		
VOCs ¹ Dilution Factor		1	1	1 st 100	1	1	1 st 20	1		

Table 5-5 Laboratory Detections of Organic Compounds in Groundwater Samples
Vermont Air National Guard Base

Area Location		Site 3 Background			Site 3		Site 4 Background	Site 4	
Sample Location		V3-BG1	V3-BG1-D	V3-MW1	V3-MW3	V4-BG1	V4-MW2	V4-MW3	
Date Sampled	Material Type	10/24/94 Groundwater		10/31/94 Groundwater	10/31/94 Groundwater	10/25/94 Groundwater	10/27/94 Groundwater	10/26/94 Groundwater	
SVOCs ² (µg/l) (a)	ARAR ²	CRQL							
bis (2-Ethylhexyl)phthalate		7	8	2 J ()	1 ()		8		
2,4-Dimethylphenol				8			6		
Di-n-butylphthalate		0.6 J					0.8 J ()		
2-Methylnaphthalene				27	0.6 ()		46		
2-Methylphenol				40					
4-Methylphenol				4 J ()					
Naphthalene				58			96 J ^d		
Phenol				3 J ()			5		
SVOCs ² Dilution Factor		1	1	1	1	1	1 ^d 2	1	
TPH ³ (mg/l) (a)	PQL								
Diesel	0.5			27	1.5				
Gasoline	0.01		0.013	12	1.4		9		
TPH ³ Dilution Factor		1	1	1	1	1	1	1	

1 VOCs - Volatile Organic Compounds - analyzed by U.S. Environmental Protection Agency (EPA) Methods 8010/8020. Analyses for dichlorobenzenes were included under both VOC Methods 8010 (Halogenated and 8020 (Aromatic).

2 Xylenes - are listed as dimethylbenzenes; 1,2-dimethylbenzene = ortho-xylene; 1,3-dimethylbenzene = meta-xylene; 1,4-dimethylbenzene = para-xylene. All concentrations in micrograms/liter (µg/l) or parts per billion (ppb).

3 ARAR - Applicable or Relevant and Appropriate Requirement; 1988 State of Vermont Groundwater Quality Standard - Preventative Action Limit in µg/l or ppb. Blanks indicate no ARAR.

4 SVOCs - Semivolatile Organic Compounds - EPA Contract Laboratory Method (CLP) Method (10/92). SVOC analyses included dichlorobenzenes. All concentrations in µg/l or ppb.

5 TPH - Total Petroleum Hydrocarbons - California Modified Method 8015. All concentrations in milligram/kilogram (mg/kg) or parts per million (ppm).

(a) No entry indicates no detection.

Shaded square containing number represents detection which exceeds State of Vermont 1988 Groundwater Quality Standard.

CRQL - Contract Required Quantitation Limit.

PQL - Practical Quantitation Limit.

Sample location - D indicates duplicate sample.

() Result is the PQL or CRQL.

J Result is estimated.

Dilution Factor: * indicates additional compound - specific dilution (e.g. *100). Not a data qualifier.

V4-MW2	
BZ	84
1,2-DBZ	25
1,3-DBZ	6.3
1,2-DMBZ	0.79
1,3-DMBZ	210
1,4-DMBZ	210
XYLENES	420.78
EBZ	160
MBE	4.9 ()
TOL	18

V3-MW1	
BZ	160
CFORM	0.082 ()
1,2-DBZ	140
1,2-DMBZ	2.3
1,3-DMBZ	520
1,4-DMBZ	520
XYLENES	1042.3
EBZ	420
TOL	840
TCE	0.24 ()

V3-BG1		DUP	
CFORM	0.17 ()	ND	0.42
TOL	0.47	J ()	0.18 ()
TCE	0.22	J ()	0.18 J ()
1,1,1-TCA	0.22 ()		

V3-MW3	
CBZ	0.54
1,2-DBZ	0.90
1,3-DBZ	2.5
1,2-DMBZ	0.73
XYLENES	0.73
EBZ	0.55
STYR	0.36

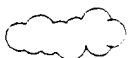
LEGEND:

—*—*—*—

FENCE

— — — — —

VERMONT AIR NATIONAL GUARD
BASE BOUNDARY



TREES



BUILDING AND BASE
NUMBER



ABOVEGROUND STORAGE TANK
AND BASE NUMBER

▲ V3-MW3

MONITORING WELL LOCATION

⊗ V3-B5

SOIL BORING LOCATION

⊗ V4-MW2/B4

MONITORING WELL/SOIL BORING
LOCATION

⊗ V4-SW3/D3

SURFACE WATER (SW) AND SEDIMENT (D)
SAMPLE LOCATION

■ V4-D2

SURFACE SEDIMENT (D) SAMPLE
LOCATION ONLY



FREE PRODUCT-NOT SAMPLED

ALL SAMPLES ANALYZED BY ENVIRONMENTAL PROTECTION
AGENCY (EPA) SW-846 METHODS 8010/8020

ALL CONCENTRATIONS IN MICROGRAMS/LITER (μg/l)
OR PARTS PER BILLION (ppb)

NO ENTRY INDICATES NO DET

DUP

()

J

520

DUPLICATE SAMP

RESULT IS BELO

QUANTITATION LI

RESULT IS ESTIM

DETECTION EXCE

GROUNDWATER C

BZ

CHLOROBENZENE

CBZ

CHLOROFORM

1,2-DBZ

1,2-DICHLOROB

1,3-DBZ

1,3-DICHLOROB

1,2-DMBZ

1,2-DIMETHYLBE

1,3-DMBZ

1,3-DIMETHYLBE

1,4-DMBZ

1,4-DIMETHYLBE

EBZ

ETHYLBENZENE

MCHL

METHYLENE CHL

MBE

METHYL-t-BUTYL

STYR

STYRENE

TOL

TOLUENE

TCE

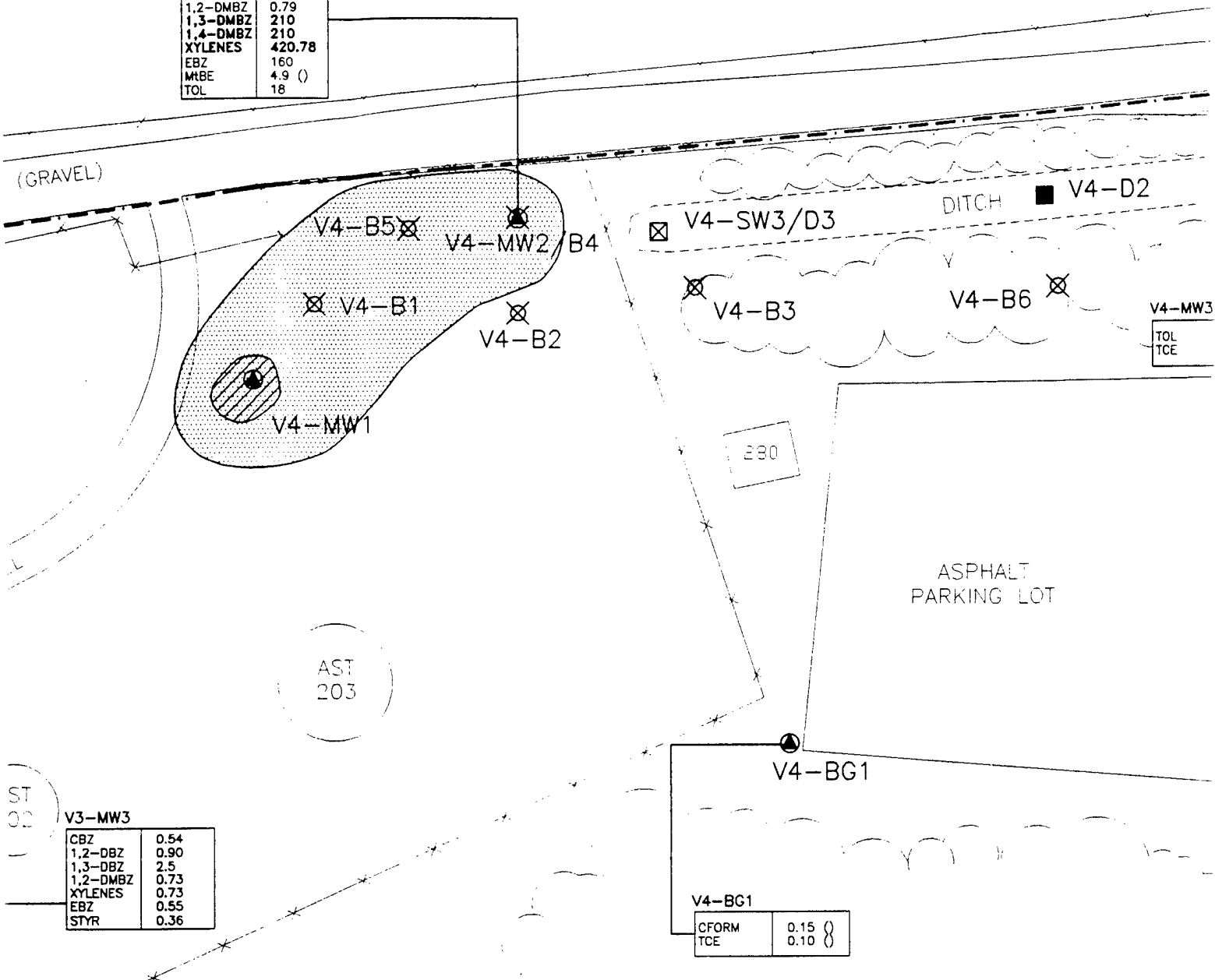
TRICHLOROETHENE

1,1,1-TCA

TRICHLOROETHAN

V4-MW2

BZ	84
1,2-DBZ	25
1,3-DBZ	6.3
1,2-DMBZ	0.79
1,3-DMBZ	210
1,4-DMBZ	210
XYLENES	420.78
EBZ	160
MTBE	4.9 ()
TOL	18



V3-MW3

CBZ	0.54
1,2-DBZ	0.90
1,3-DBZ	2.5
1,2-DMBZ	0.73
XYLENES	0.73
EBZ	0.55
STYR	0.36

V4-BG1

CFORM	0.15 ()
TCE	0.10 ()

NO ENTRY INDICATES NO DETECTION

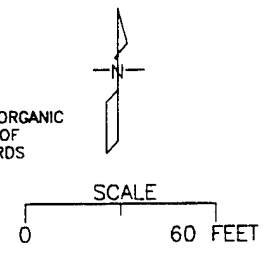
DUP () DUPLICATE SAMPLE
 RESULT IS BELOW PRACTICAL QUANTITATION LIMIT

J RESULT IS ESTIMATED

520 DETECTION EXCEEDS 1988 STATE OF VERMONT GROUNDWATER QUALITY STANDARD

SEDIMENT (D)	BZ	BENZENE
	CBZ	CHLORO BENZENE
	CFORM	CHLOROFORM
IPLE	1,2-DBZ	1,2-DICHLORO BENZENE
	1,3-DBZ	1,3-DICHLORO BENZENE
	1,2-DMBZ	1,2-DIMETHYL BENZENE
ED	1,3-DMBZ	1,3-DIMETHYL BENZENE
	1,4-DMBZ	1,4-DIMETHYL BENZENE
ON	EBZ	ETHYL BENZENE
	MCHL	METHYLENE CHLORIDE
	MTBE	METHYL-t-BUTYL ETHER
	STYR	STYRENE
	TOL	TOLUENE
	TCE	TRICHLOROETHENE
	1,1,1-TCA	TRICHLOROETHANE

APPROXIMATE AREA OF DISSOLVED-PHASE GROUNDWATER CONTAMINATION: VOLATILE ORGANIC COMPOUNDS IN EXCESS OF 1988 STATE OF VERMONT GROUNDWATER QUALITY STANDARDS



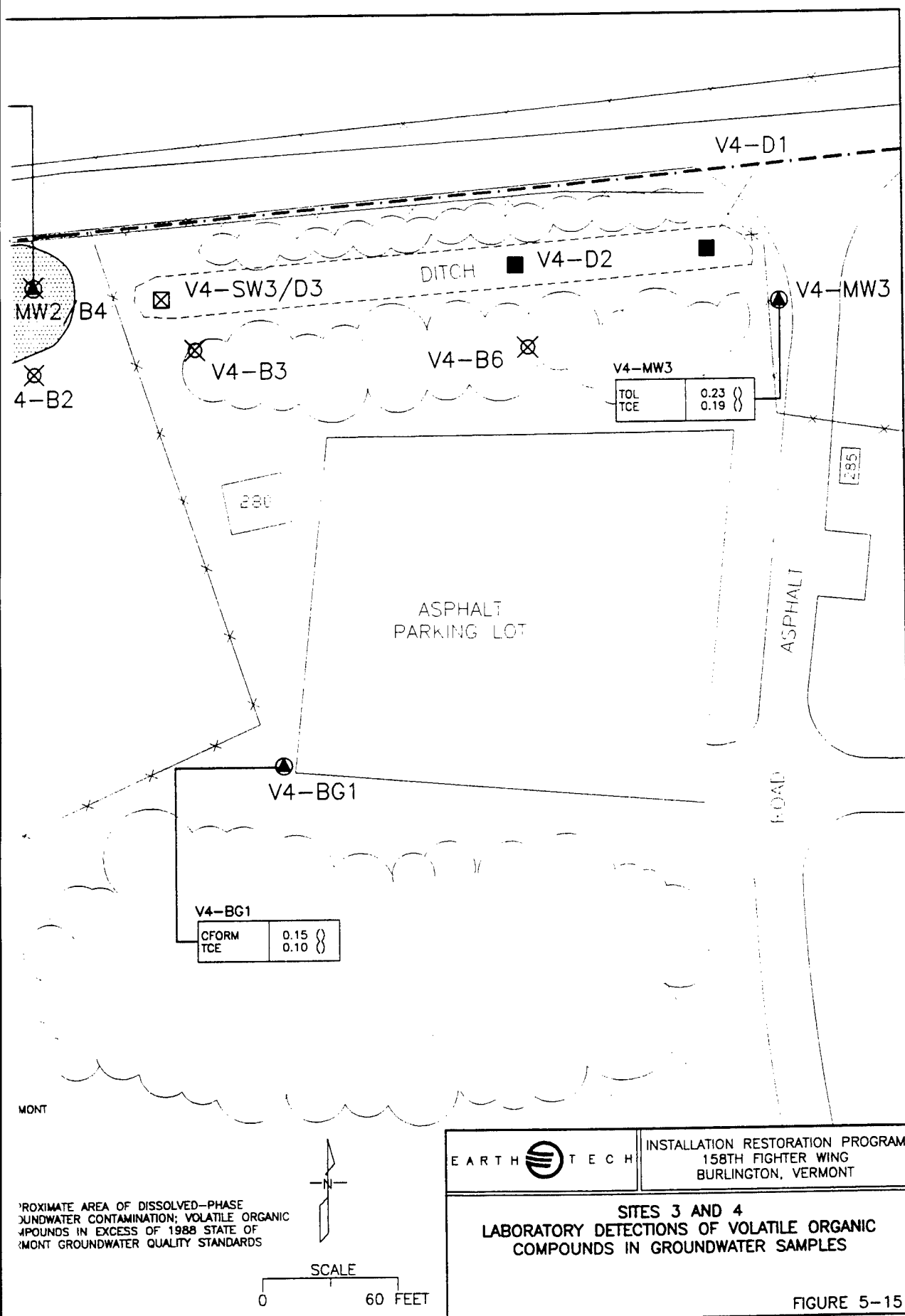
EARTH TECH

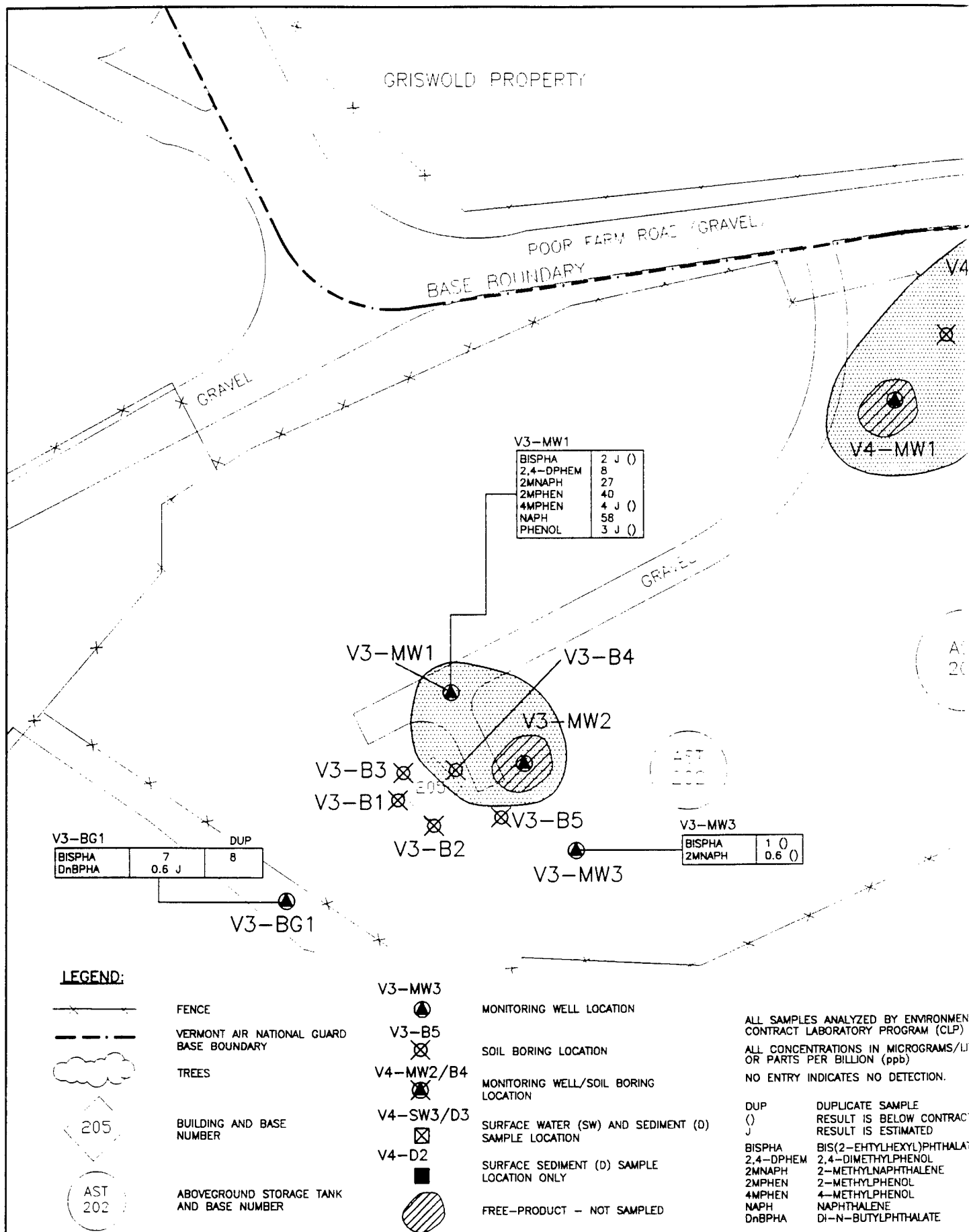
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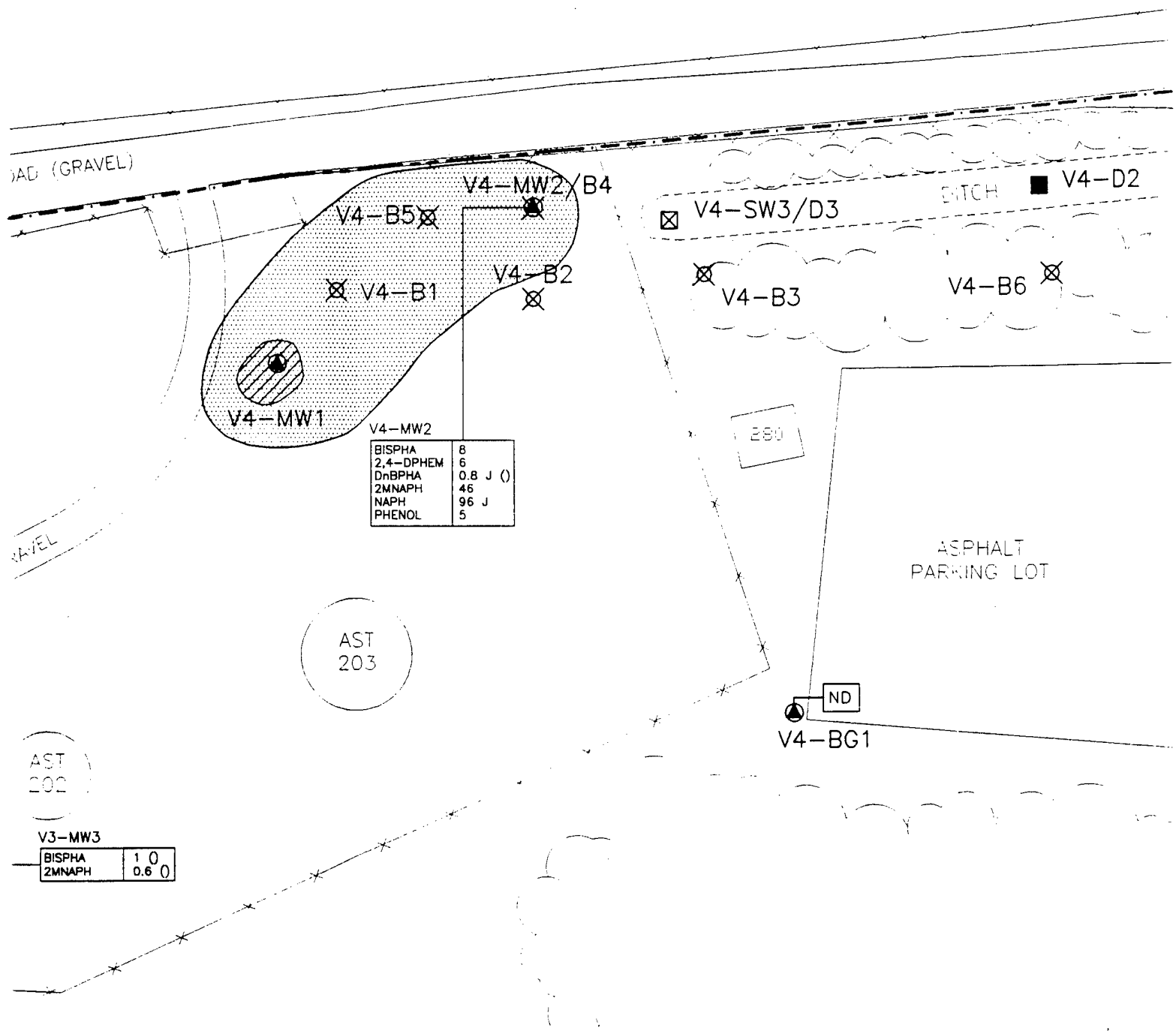
SITES 3

LABORATORY DETECTIONS

COMPOUNDS IN GRO







V4-MW2

BISPHA	8
2,4-DPHEM	6
DnBPBA	0.8 J ()
2MNAPH	46
NAPH	96 J
PHENOL	5

V3-MW3

BISPHA	1.0
2MNAPH	0.6 ()

ALL SAMPLES ANALYZED BY ENVIRONMENTAL PROTECTION AGENCY (EPA)
CONTRACT LABORATORY PROGRAM (CLP) METHODS, 10/92 REVISION

ALL CONCENTRATIONS IN MICROGRAMS/LITER (µg/l)
OR PARTS PER BILLION (ppb)

NO ENTRY INDICATES NO DETECTION.

DUP	DUPLICATE SAMPLE
()	RESULT IS BELOW CONTRACT REQUIRED DETECTION LIMIT
J	RESULT IS ESTIMATED
BISPHA	BIS(2-ETHYLHEXYL)PHTHALATE
2,4-DPHEM	2,4-DIMETHYLPHENOL
2MNAPH	2-METHYLNAPHTHALENE
2MPHEN	2-METHYLPHENOL
4MPHEN	4-METHYLPHENOL
NAPH	NAPHTHALENE
DnBPBA	DI-N-BUTYLPHTHALATE



APPROXIMATE AREA OF DISSOLVED-PHASE
GROUNDWATER CONTAMINATION; VOLATILE ORGANIC
COMPOUNDS IN EXCESS OF 1988 STATE OF
VERMONT GROUNDWATER QUALITY STANDARDS

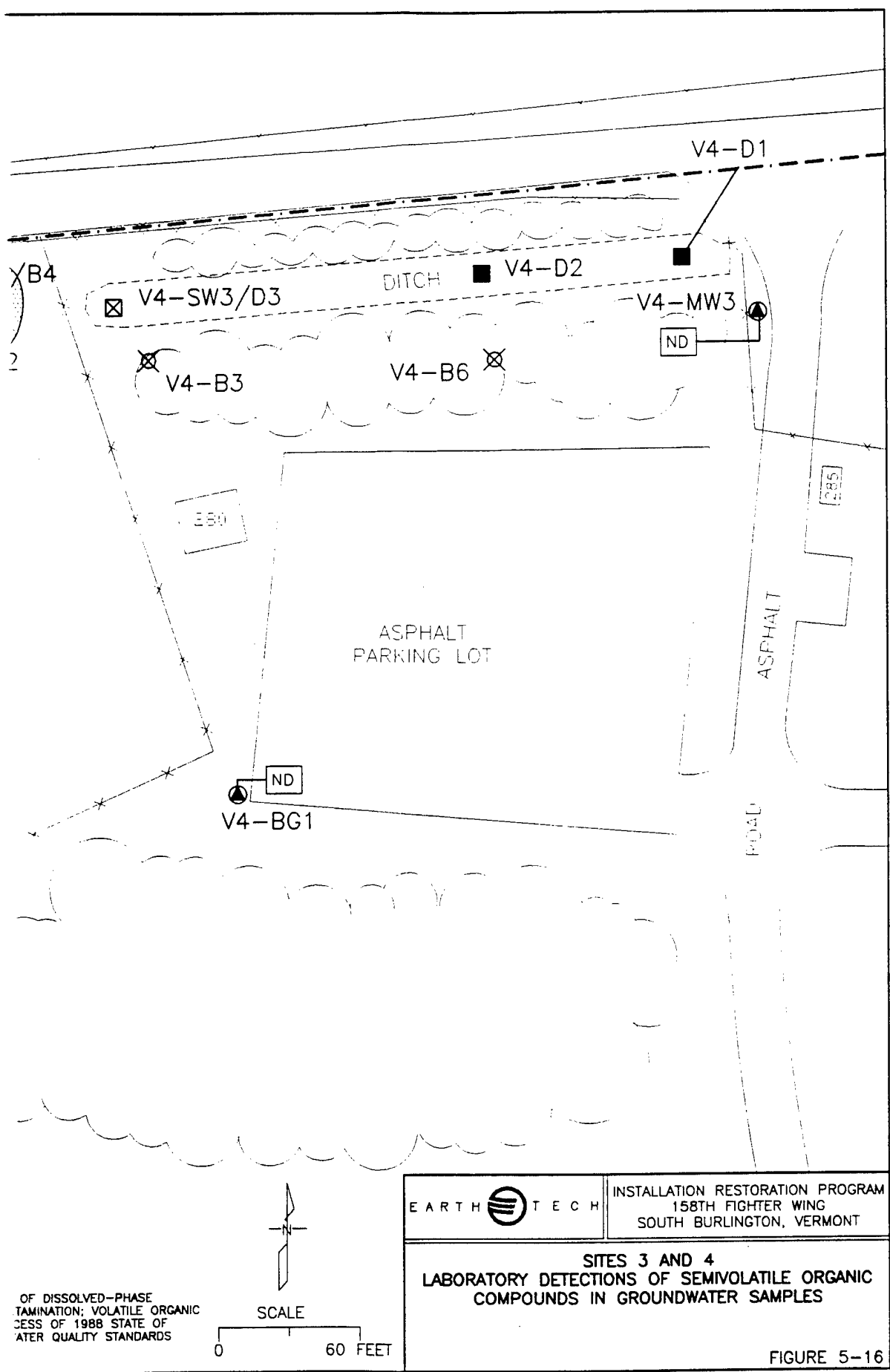


SCALE

0 60 FEET

EARTH  TECH INC.

SITES
LABORATORY DETECTION
COMPOUNDS IN C



OF DISSOLVED-PHASE
TAMINATION; VOLATILE ORGANIC
CESS OF 1988 STATE OF
ATER QUALITY STANDARDS


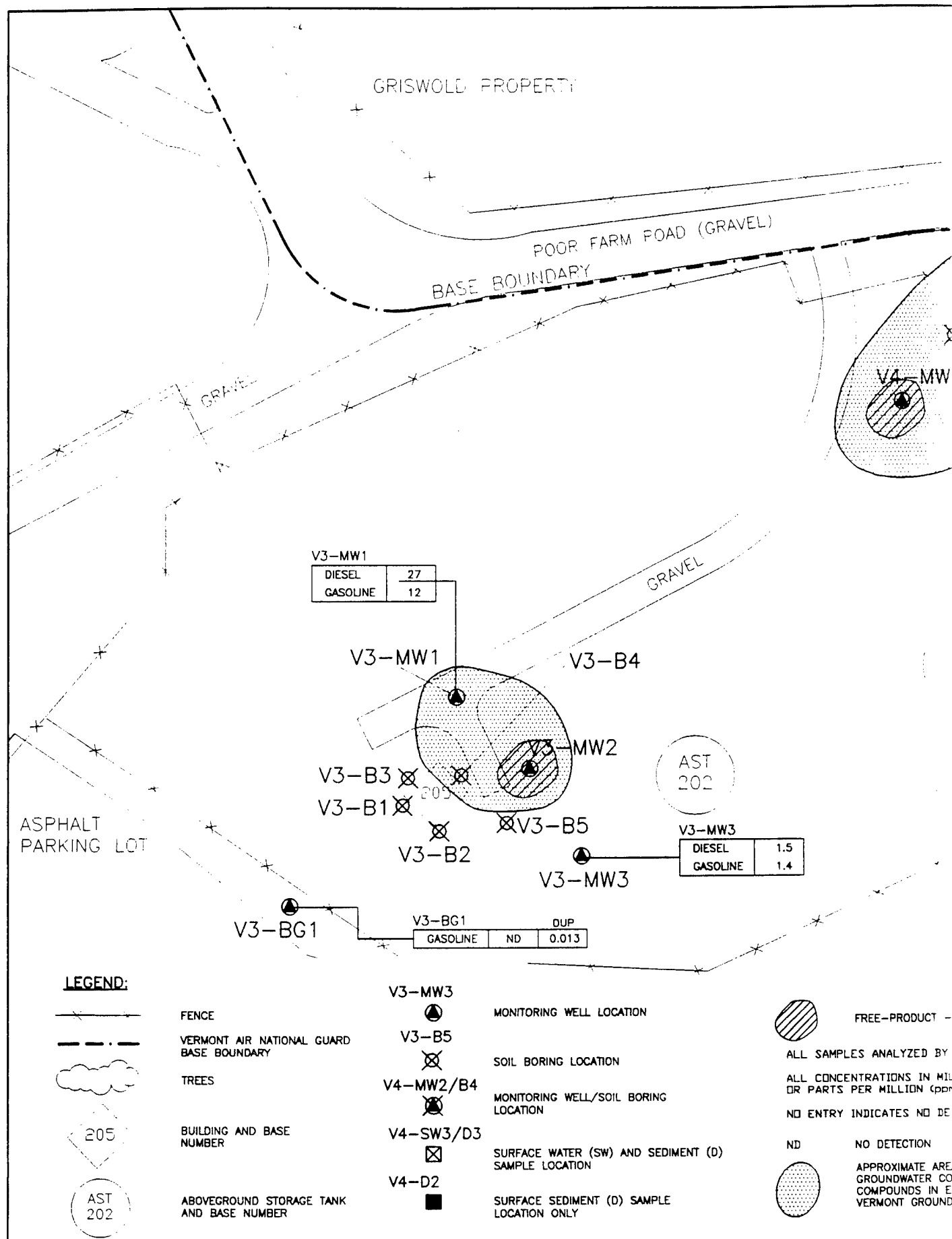
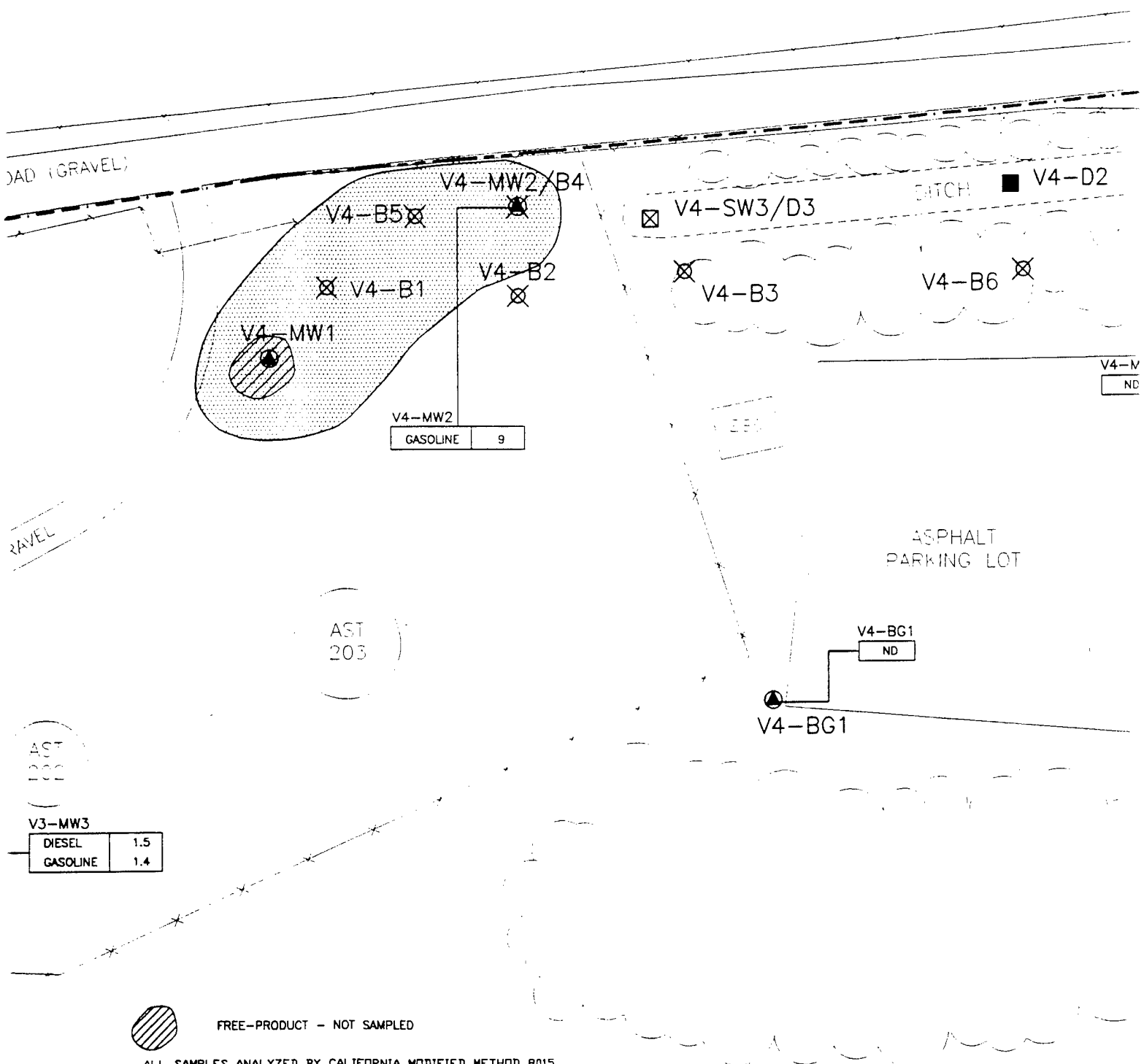
EARTH  TECH	INSTALLATION RESTORATION PROGRAM 158TH FIGHTER WING SOUTH BURLINGTON, VERMONT
	SITES 3 AND 4 LABORATORY DETECTIONS OF SEMIVOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

FIGURE 5-16





FREE-PRODUCT - NOT SAMPLED

ALL SAMPLES ANALYZED BY CALIFORNIA MODIFIED METHOD 8015

ALL CONCENTRATIONS IN MILLIGRAMS/LITER (mg/l)
OR PARTS PER MILLION (ppm)

NO ENTRY INDICATES NO DETECTION.

ND

NO DETECTION



APPROXIMATE AREA OF DISSOLVED-PHASE
GROUNDWATER CONTAMINATION; VOLATILE ORGANIC
COMPOUNDS IN EXCESS OF 1988 STATE OF
VERMONT GROUNDWATER QUALITY STANDARDS

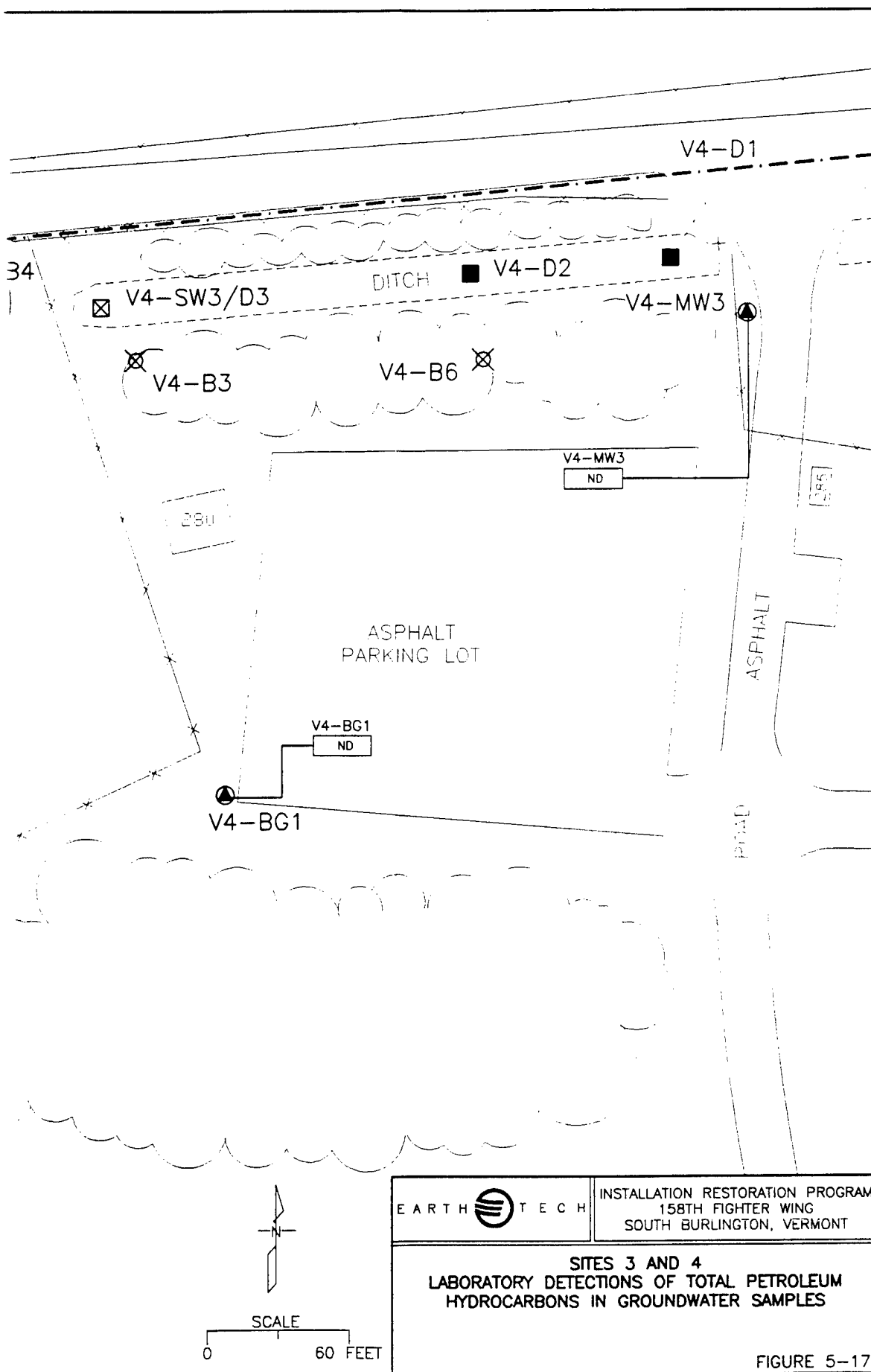


SCALE

0 60 FEET

EARTH TECH

SITE
LABORATORY DETECTION
HYDROCARBONS IN



in Table 5-5. Complete listings of compounds and laboratory analytical results are presented in Appendix J.

VOCs

Laboratory analyses for VOCs in groundwater samples were conducted according to EPA SW-846 Methods 8010/8020 (EPA 1986). VOCs analyses included analysis for aromatic VOCs (Method 8010) and for halogenated VOCs (Method 8020). Analyses for dichlorobenzenes were included under both Methods 8010 and 8020. CLP 10/92 analyses for SVOCs does not include dichlorobenzenes. Detections of dichlorobenzenes were limited to Method 8020 results; therefore, the detections are suspect. Detections of VOCs in groundwater samples, reported in $\mu\text{g}/\ell$ or ppb, are summarized in Table 5-5 and Figure 5-15.

Detections of VOCs in groundwater samples from Site 3 background monitoring well V3-BG1 were limited to low concentrations (less than 1 ppb) of toluene, TCE, and 1,1,1-TCA. The detections of TCE (0.15 $\mu\text{g}/\ell$ and 0.18 $\mu\text{g}/\ell$ ppb), toluene (0.42 and 0.47 ppb), and 1,1,1-TCA (0.18 $\mu\text{g}/\ell$ and 0.22 $\mu\text{g}/\ell$ ppb) are below PQLs and/or respective State of Vermont PPALs (0.5 ppb, 1021 ppb, and 100 ppb).

Detections of VOCs in groundwater samples from Site 3 monitoring wells (V3-MW1 and V3-MW3) ranged from low to high concentrations, with three analyte detections in excess of State of Vermont Groundwater Quality Standards. Detections in well V3-MW3 were limited to low concentrations (most less than 1 ppb) of chlorobenzene, 1,2- and 1,3-dichlorobenzene, 1,2-dimethylbenzene, ethylbenzene, and styrene. Well V3-MW3 is not directly hydraulically downgradient of the suspected source area (Building 205) (Figure 5-6). In contrast, wells V3-MW1 and V3-MW2 are located directly hydraulically downgradient of the suspected source area (Figures 5-6 and 5-7). Free-product was measured in well V3-MW2. In well V3-MW1, low detections (less than PQLs or 10 ppb) included those for chloroform (0.082 $\mu\text{g}/\ell$ ppb), 1,2-dimethylbenzene (2.3 ppb), and TCE (0.24 $\mu\text{g}/\ell$ ppb, below the State of Vermont PPAL of 0.5 ppb), and high detections (in excess of 100 ppb) included 160 ppb benzene (160 ppb), 1,2-dichlorobenzene (140 ppb), 1,3- and 1,4-dimethylbenzenes (520 ppb each), ethylbenzene (420 ppb), and toluene (840 ppb). Of these high detections, 160 ppb benzene, and 1,042 ppb total xylenes (dimethylbenzenes) exceed State of Vermont PESs (5 ppb for benzene and 400 ppb for total xylenes), and 420 ppb ethylbenzene exceeds the State of Vermont PPAL of 340 ppb.

Detections of VOCs in groundwater samples from Site 4 background monitoring well V4-BG1 were limited to low concentrations (less than 1 ppb and PQLs) of chloroform (0.15 $\mu\text{g}/\ell$ ppb) and TCE (0.1 $\mu\text{g}/\ell$ ppb, below the State of Vermont PPAL of 0.5 ppb).

Detections of VOCs in groundwater samples from Site 4 monitoring wells (V4-MW2 and V4-MW3) ranged from low to high concentrations, with two detections in excess of State of Vermont Groundwater Quality Standards. Detections in well V4-MW3 were limited to low concentrations (less than 1 ppb and PQLs) of toluene (0.23 $\mu\text{g}/\ell$ ppb) and TCE (0.19 $\mu\text{g}/\ell$ ppb, below the State of Vermont PPAL of 0.5 ppb). Well V4-MW3 is the easternmost monitoring well in Site 4 and is not proximal to the suspected source area, located in the western portion of the site. Wells V4-MW1 and V4-MW2 are located proximal to the suspected source area. Free-product was measured in well V4-MW1. In well V4-MW2, low detections included: 1,2-

dichlorobenzene (25 ppb), 1,3-dichlorobenzene (6.3 ppb), 1,2-dimethylbenzene (0.79 ppb), methyl-t-butylether (4.9 () ppb), and toluene (18 ppb); and high detections (most in excess of 100 ppb) included benzene (84 ppb), 1,3- and 1,4-dimethylbenzenes (210 ppb each), and ethylbenzene (160 ppb). Of these high detections, benzene and total xylenes (dimethylbenzenes) detections are the most significant, as they exceed State of Vermont PESs (5 ppb for benzene and 400 ppb for total xylenes).

SVOCs

Laboratory analyses for SVOCs in groundwater samples were conducted according to EPA CLP Methods, 10/92 Revision (EPA 1992). Detections of SVOCs in groundwater samples, reported in $\mu\text{g}/\ell$ or ppb, are summarized in Table 5-5 and Figure 5-16.

Detections of SVOCs in groundwater from Site 3 background monitoring well V3-BG1 were limited to a low concentration (less than 1 ppb) of di-n-butylphthalate (0.6 J ppb), and low concentrations of bis(2-ethylhexyl)phthalate (7 and 8 ppb). These detections are not considered significant.

Detections of SVOCs in groundwater samples from Site 3 monitoring wells (V3-MW1 and V3-MW3) ranged from low to higher concentrations (all less than 100 ppb). Detections in well V3-MW3 were limited to low concentrations of 2-methylnaphthalene (0.6 () ppb) and bis(2-ethylhexyl)phthalate (1 () ppb). Both detections are below the CRQLs and are not considered significant. Detections of SVOCs in well V3-MW1 were limited to concentrations (less than 100 ppb) of bis(2-ethylhexyl)phthalate (2 J ppb), 2,4-dimethylphenol (8 ppb), 2-methylnaphthalene (27 ppb), 2-methylphenol (40 ppb), 4-methylphenol (4 J ppb), naphthalene (58 ppb), and phenol (3 J ppb).

No detections of SVOCs were indicated in groundwater from Site 4 background monitoring well V4-BG1. No detections of SVOCs were also indicated in Site 4 monitoring well V4-MW3.

Detections of SVOCs in Site 4 were limited to well V4-MW2, located near the suspected source area, and consisted of low (less than 1 ppb) to higher (less than 100 ppb) concentrations. Low detections were limited to one detection of di-n-butylphthalate (0.8 J ppb). Higher detections consisted of bis(2-ethylhexyl)phthalate (8 ppb), 2,4-dimethylphenol (6 ppb), 2-methylnaphthalene (46 ppb), naphthalene (96 J ppb), and phenol (5 ppb).

TPH

Laboratory analyses for TPH in groundwater samples were conducted according to California Modified Method 8015 (California 1988). Detections of TPH (diesel and gasoline) in groundwater samples, reported in mg/ℓ or ppm, are summarized in Table 5-5 and Figure 5-17.

Detection of TPH in groundwater from Site 3 background monitoring well V3-BG1 was limited to a low concentration of gasoline (0.013 ppm). This detection is not considered significant.

Detections of TPH in groundwater samples from Site 3 monitoring wells (V3-MW1 and V3-MW3) exceeded 1 ppm for both TPH diesel and TPH gasoline. Detections in well V3-MW3 consisted of 1.5 ppm TPH diesel and 1.4 ppm TPH gasoline. Similar to results for VOCs and

SVOCs, TPH detections in Site 3 were highest in well V3-MW1, with 27 ppm TPH diesel and 12 ppm TPH gasoline.

No detection of TPH in groundwater was indicated in Site 4 background monitoring well V4-BG. No detection of TPH in groundwater was also indicated in Site 4 monitoring well V4-MW3.

One detection of TPH gasoline (9 ppm) was indicated in well V4-MW2, located near the suspected source area. Well V4-MW2 similarly featured the highest detections of VOCs and SVOCs. No TPH diesel component was detected at Site 4.

Free-Product

Water-level and free-product measurements were made on October 5-6 and 21-22, 1994 (Table 5-1 and Figures 5-6 and 5-7). On October 6, 1994, detected free-product was limited to 2.69 ft in Site 3 well V3-MW2, and a hydrocarbon sheen on well development water from Site 4 well V4-MW2. On October 21-22, 1994, free-product was measured in both wells; 0.01 ft in V3-MW2 and 1.07 ft in V4-MW1. Site 4 well V4-MW1 is hydraulically downgradient from Site 3 well V3-MW2. Vertical free-product migration in the capillary zone of subsurface soils adjacent to well screens is typically affected by variations in water levels; higher water levels can temporarily block entry of free-product into well screens, and lower water levels can expose more area of free-product contaminated soils to well screens. Water levels across both sites were slightly lower (by 0.01 to 0.1 in.) in most wells on October 21-22 (Table 5-1); however, the impact of this on the significant variations in free-product thicknesses is not apparent. Local horizontal migration of free-product in the vicinity of each well is a consideration.

5.2.4.2 Inorganics - Groundwater

Laboratory analyses for TAL metals in groundwater samples were conducted according to EPA CLP methods, 3/90 Revision (EPA 1990b). Base-wide background values for total TAL metals in upper overburden aquifer groundwater were determined from a statistical evaluation of detections in unfiltered groundwater samples from two SRI and two ASI background monitoring wells; well V1-RFW1A in IRP Site 1 (one sample), well V2-BG1 in IRP Site 2 (one sample), well V3-BG1 in IRP Site 3 (one sample and one duplicate sample), and well V4-BG1 in IRP Site 4 (one sample). SRI groundwater sampling was conducted in May 1995 and ASI groundwater sampling was conducted in October 1994. Approximate locations of base-wide background monitoring wells are presented on Figure 1-2. The sample and duplicate sample from Site 3 well V3-BG1 were averaged together to generate one value for that location. It is estimated that the background locations, being hydraulically up-gradient of suspected source areas, best reflect average base-area concentrations of TAL metals in groundwater. Generally, background and source area analytical detections for TAL metals are comparable, however, some variations are indicated. Background values, for each TAL metal were calculated by averaging analytical detections from the four monitoring wells, or as otherwise indicated.

No detections were indicated for seven of the 23 TAL metals, in all background upper overburden aquifer groundwater samples; antimony, beryllium, cadmium, mercury, silver, selenium and thallium. Based on background monitoring well detections and the background

value criteria presented in Section 5.2.3.2, background concentrations were determined for all 23 TAL metals. The groundwater sample from Site 1 background well V1-RFW1A featured the highest background detections for 15 of the 22 detected TAL metals, including: aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. The background value for calcium was based on the highest detection in the groundwater sample from Site 4 background well V4-BG1. It should be noted that concentrations in excess of background values not necessarily anomalous, particularly considering the probable effects of local geologic/hydrogeologic conditions. The background values, calculated from analytical results from only four locations, are best utilized as general reference values to aid in identifying possibly anomalous concentrations. Some background concentrations were less than CRDLs (detections qualified with (I)) and therefore considered estimates. State of Vermont Primary and Secondary Groundwater Quality Standards, available for some TAL metals, are compared to background values and used to identify possibly anomalous concentrations. Base-wide background values for arsenic (39.7 ppb), chromium (108 ppb), iron (103,000 ppb), lead (39.9 ppb), and manganese (3,770 ppb) exceeded respective State of Vermont Groundwater Quality Standards; the PPAL for arsenic (25 ppb), the PES for chromium (50 ppb), the Secondary Enforcement Standard (SES) for iron (300 ppb), the PPAL for lead (10 ppb), and the SES for manganese (50 ppb). Detections of manganese (from six total samples and five dissolved samples) exceeded the PES in all six ASI monitoring wells. Similarly, detections of iron (from six total samples and one dissolved sample) exceeded the SES in all six ASI monitoring wells. Lead was not detected in background monitoring wells for Site 3 (V3-BG1) and Site 4 (V4-BG1); however, detections of lead exceeded State of Vermont Groundwater Quality Standards in groundwater samples from all four ASI site area wells.

Base-wide background values for total TAL metals in groundwater and available State of Vermont Groundwater Quality Standards are presented in Table 5-6. Analytical detections of TAL metals (total and dissolved) in groundwater samples from ASI background and source area monitoring wells are presented in Table 5-7. Concentrations equal to or in excess of applicable background values or State of Vermont Groundwater Quality Standards (Vermont 1988) are highlighted in Table 5-7. Applicable ARARs are presented in Table 5-7 and in Appendix G. Figure 5-18 presents these highlighted total and dissolved concentrations of TAL metals in groundwater. Detections which exceed ARARs are highlighted in Figure 5-18. Applicable background values are presented in Table 5-7. TAL metal detections in groundwater are reported in $\mu\text{g/l}$ or ppb.

The number of dissolved (filtered) TAL metal detections were significantly less than the number of total (unfiltered) TAL metal detections in every ASI groundwater sample. Many TAL metals detected in total samples were not detected in dissolved samples. Detections of dissolved TAL metals were limited to arsenic, calcium, cobalt, iron, magnesium, manganese, nickel, potassium, sodium, and zinc. TAL metal detections (total and dissolved samples) which exceeded State of Vermont Groundwater Quality Standards were limited to arsenic (PES of 50 ppb), chromium (PPAL of 25 ppb), iron (SES of 300 ppb), lead (PES of 20 ppb and PPAL of 10 ppb), and manganese (SES of 50 ppb). Complete listings of all ASI analytes and laboratory analytical results are presented in Appendix J. Complete listings of SRI and ASI analytical results for inorganics in groundwater samples from background monitoring wells in IRP Sites 1 through 4 are presented in Appendix K. TAL metal detections (total and dissolved)

**Table 5-6 Base-Wide Background Values for Inorganic Analytes in Groundwater
Supplemental Remedial Investigation - Installation Restoration Program Sites 1 and 2
Vermont Air National Guard Base**

TAL ¹ Metals (µg/l)	UOA Background Mean ^(a)	UOA Background Value ^(b)	Vermont Groundwater Enforcement Standard ^(c)	Vermont Groundwater Preventative Action Limit ^(c)
Aluminum	18,400	58,400 ⁽¹⁾		
Antimony	24.6	25.4 ^(b)		
Arsenic	39.7	39.7 ⁽¹⁾	50	25 *
Barium	129	363 ⁽¹⁾	1000	500
Beryllium	0.02	0.25 ^(b)		
Cadmium	2.18	2.2 ^(b)	5	2.5
Calcium	53,500	109,000 ⁽¹⁾		
Chromium	45.9	108 ⁽¹⁾	50 *	25 *
Cobalt	21.4	69.8 ⁽¹⁾		
Copper	52.7	128 ⁽¹⁾	1000	500
Iron	33,200	103,000 ⁽¹⁾	300 *	150 *
Lead	15.0	39.9 ⁽¹⁾	20 *	10 *
Magnesium	16,300	29,700 ⁽¹⁾		
Manganese	1,410	3,770 ⁽¹⁾	50 *	25 *
Mercury	ND	0.1 ⁽²⁾	2	1
Nickel	52.3	154 ⁽¹⁾	350	175
Potassium	3,960	10,000 ⁽¹⁾		
Selenium	7.6	14 ^(b)		
Silver	1.9	2.1 ^(b)	50	25
Sodium	83,100	166,000 ⁽¹⁾		
Thallium	9.9	18 ^(b)		
Vanadium	35.7	112 ⁽¹⁾		
Zinc	94.6	280 ⁽¹⁾	5000	2500

¹ TAL Metals - Target Analyte List metals - analyzed by U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3/90). All concentrations in micrograms/liter (µg/l) or parts per billion (ppb) based on analytical results for total (unfiltered) groundwater samples.

^(a) Background Mean calculated from base-wide background upper overburden groundwater analytical results from Site 1 well V1-RFW1A, Site 2 well V2-BG1, Site 3 well V3-BG1, and Site 4 well V4-BG1.

^(b) Background Value is equal to the Background Mean plus two Standard Deviations, or as indicated below (1, 2, or 3).

⁽¹⁾ If Background Mean plus two Standard Deviations > Maximum Background Detection, then Background Value = Maximum Background Detection.

⁽²⁾ If TAL metal was not detected in background samples, the Background Value = ½ (average sample-specific Contract Required Detection Limit).

⁽³⁾ Background Value was based on one detection. The detection equals Background Mean/Value.

^(c) Primary and Secondary Groundwater Quality Standards from State of Vermont, Chapter 12 Groundwater Protection Rule and Strategy, September 1988. Blanks indicate no values are available.

* Denotes Groundwater Quality Standard was exceeded by Background Value(s).

UOA Upper Overburden (water table) Aquifer

ND Analyte not detected in background groundwater samples.

Area Location		Site 3 Background						Site 3		
Sample Location		V3-BG1			V3-BG1-D		V3-MW1		V3-MW3	
Date Sampled Material Type Total or Dissolved	Background ²	ABAR ³	CRDL	10/24/94 Groundwater Total	10/24/94 Groundwater Dissolved	10/24/94 Groundwater Total	10/24/94 Groundwater Dissolved	10/31/94 Groundwater Total	10/31/94 Groundwater Dissolved	10/31/94 Groundwater Dissolved
TAL ¹ Metals (ug/l) (a)										
Aluminum	58400		200	3860 J		3230 J		6190 J		4840 J
Arsenic	39.7		10					2.9 J ()		
Barium	363	500	200	35.0 ()	7.9 ()	32.4 ()	8.1 ()	153 ()	28.4 ()	98.3 ()
Beryllium	0.25		5					0.85 J ()		
Calcium	109000		5000	54800		53400	51500	170000	94200	141000
Chromium	108	25	10	9.8 ()		7.3 ()		8.8 ()		10.1
Cobalt	69.8		50					62.1	14.4 J ()	21.1 ()
Copper	128	500	25	23.5 ()		21.6 ()		82.7		38.3
Iron	103000	150	100	9810		8000		7560		5290
Lead	39.9	10	3	7.2 J		6.2 J		25.1		21.3
Magnesium	29700		5000	9660	7880			29700	20800	16500
Manganese	3770	25	15	553	81.6	540	82.0	7340	2840	10200
Nickel	154	175	40			19.9 ()		96.2		38.2 ()
Potassium	10000		5000	1890 ()	1170 ()	1620 ()	1010 ()	2350 ()	1660 ()	3990 ()
Sodium	166000		5000	109000	103000	98100	101000	309000	254000	228000
Vanadium	112		50	8.7 ()		7.4 ()		7.3 ()		
Zinc	280	2500	20	28.3		28.3		107 J		46.0 J
TAL ¹ Metals Dilution Factor				1	1	1	1	1	1	1

Area Location			Site 3 Background						Site 3			
Sample Location			V3-BG1		V3-BG1-D		V3-MW1		V3-MW3			
Date Sampled Material Type Total or Dissolved	Background ²	ABAR ³	CRDL	10/24/94 Groundwater Total	10/24/94 Groundwater Dissolved	10/24/94 Groundwater Total	10/24/94 Groundwater Dissolved	10/31/94 Groundwater Total	10/31/94 Groundwater Dissolved	10/31/94 Groundwater Total	10/31/94 Groundwater Dissolved	
TAL ¹ Metals (ug/l) (a)												
Aluminum	58400		200	3860 J		3230 J		6190 J		4840 J		
Arsenic	39.7		10					2.9 J ()				
Barium	363	500	200	35.0 ()	7.9 ()	32.4 ()	8.1 ()	153 ()	28.4 ()	98.3 ()	28.1 ()	
Beryllium	0.25		5					0.85 J ()				
Calcium	109000		5000	54800		53400	51500	170000	94200	141000	106000	
Chromium	108	25	10	9.8 ()		7.3 ()		8.8 ()		10.1	7.3 ()	
Cobalt	69.8		50					62.1	14.4 J ()	21.1 ()		
Copper	128	500	25	23.5 ()		21.6 ()		82.7		38.3		
Iron	103000	150	100	9810		8000		7560		5290		
Lead	39.9	10	3	7.2 J		6.2 J		25.1		21.3		
Magnesium	29700		5000	9660	7880			29700	20800	16500	13400	
Manganese	3770	25	15	553	81.6	540	82.0	7340	2840	10200	7730	
Nickel	154	175	40			19.9 ()		96.2		38.2 ()		
Potassium	10000		5000	1890 ()	1170 ()	1620 ()	1010 ()	2350 ()	1660 ()	3990 ()	3250 ()	
Sodium	166000		5000	109000	103000	98100	101000	308000	254000	228000	203000	
Vanadium	112		50	8.7 ()		7.4 ()		7.3 ()				
Zinc	280	2500	20	28.3		28.3		107 J		46.0 J		
TAL ¹ Metals Dilution Factor				1	1	1	1	1	1	1	1	

**Table 5-7 Laboratory Detections of Inorganic Analytes in Groundwater Samples
Vermont Air National Guard Base**

Area Location			Site 4 Background			Site 4				
Sample Location			V4-BG1			V4-MW2		V4-MW3		
Date Sampled Material Type Total or Dissolved	TAL ¹ Metals (µg/l) (a)	Background ²	ARAR ³	CRDL	10/25/94 Groundwater Total	10/25/94 Groundwater Dissolved	10/27/94 Groundwater Total	10/27/94 Groundwater Dissolved	10/26/94 Groundwater Total	10/26/94 Groundwater Dissolved
Aluminum		58400		200	7960 J		5380 J		11700 J	
Arsenic		39.7		11			67.9	56.4 J	19.6 J	
Barium		363		200	98.9 ()	51.9 ()	81.1 ()	59.3 ()	126 ()	28.1 ()
Beryllium		0.25		5					0.75 ()	
Calcium		109000		5000	109000	136000	102000	110000	79500	74500
Chromium		108		10	21.1		17.0		26.5	
Cobalt		69.8		50			15.5 ()		18.8 ()	
Copper		128		25	19.2 ()		39.4			
Iron		103000		100	11600		54300	33600 J	25400	
Lead		39.9		3	5.5 J		12.6 J		32.0 J	
Magnesium		29700		5000	20100	19400	16500	14700		
Manganese		3770		15	1030	1040	4750	4940	1780	150
Nickel		154		40	24.9 ()		22.5 ()		53.9	
Potassium		10000		5000	3450 ()	2090 ()	2550 ()		9370	4280 ()
Sodium		166000		5000	60000	83800	117000	131000	668750	1850000
Vanadium		112		50	13.2 ()		17.4 ()		24.3 ()	
Zinc		280		20	37.6		44.6	7.1 J ()	113	
TAL ¹ Metals Dilution Factor					1	1	1	1	1	1

¹TAL Target Analyte List Metals - Analyzed by U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3/90). All concentrations in micrograms/liter µg/l or parts per billion (ppb).

(a) No entry indicates no detection.

² Background value.

³ ARAR - Applicable or Relevant and Appropriate Requirement; 1988 State of Vermont Groundwater Quality Standard - Preventative Action Limit in µg/l or ppb. Blanks indicate no ARAR.

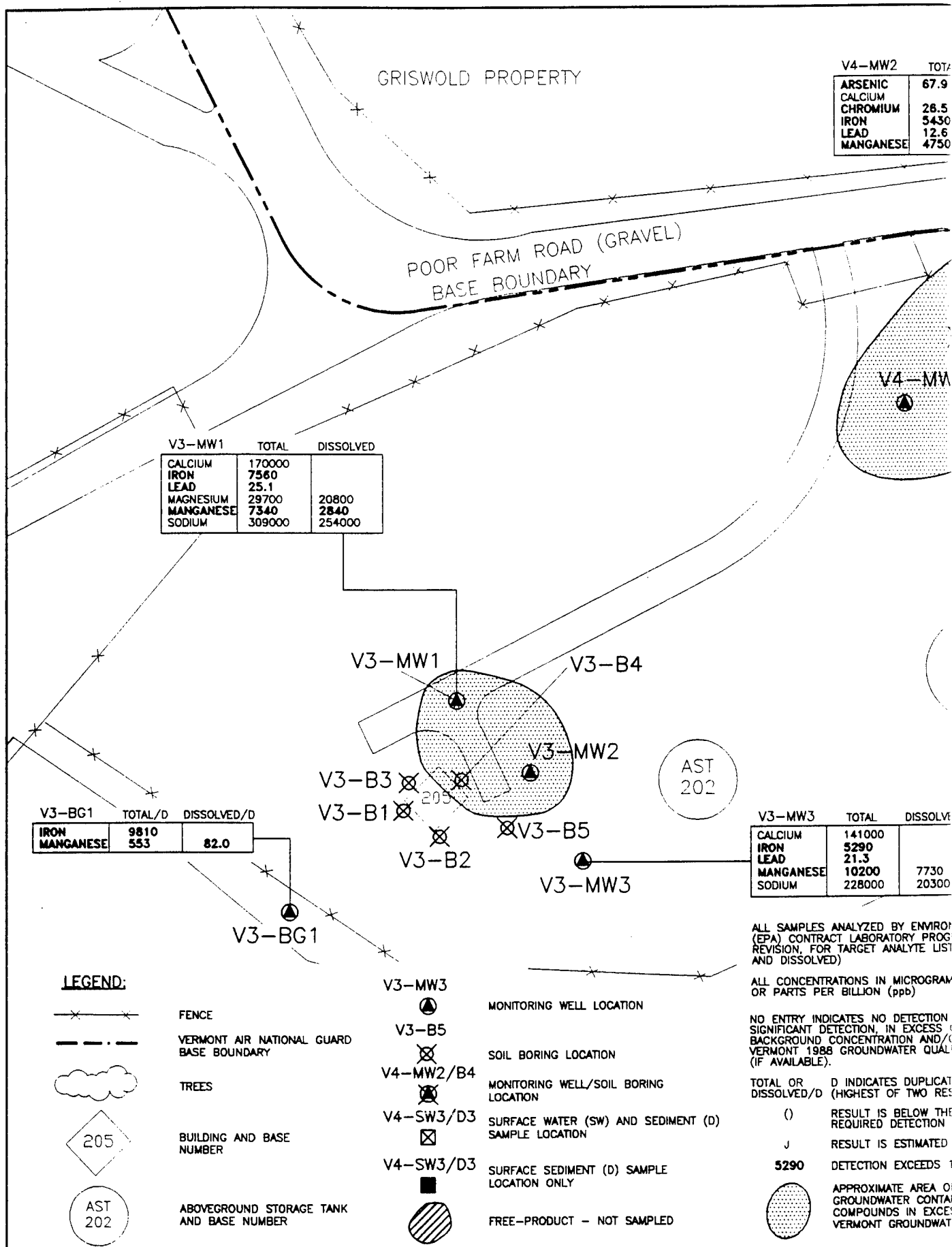
CRDL Contract Required Detection Limit.

Shaded squares containing numbers represent detections in site monitoring wells above background values and/or State of Vermont 1988 Groundwater Quality Standards (if available).

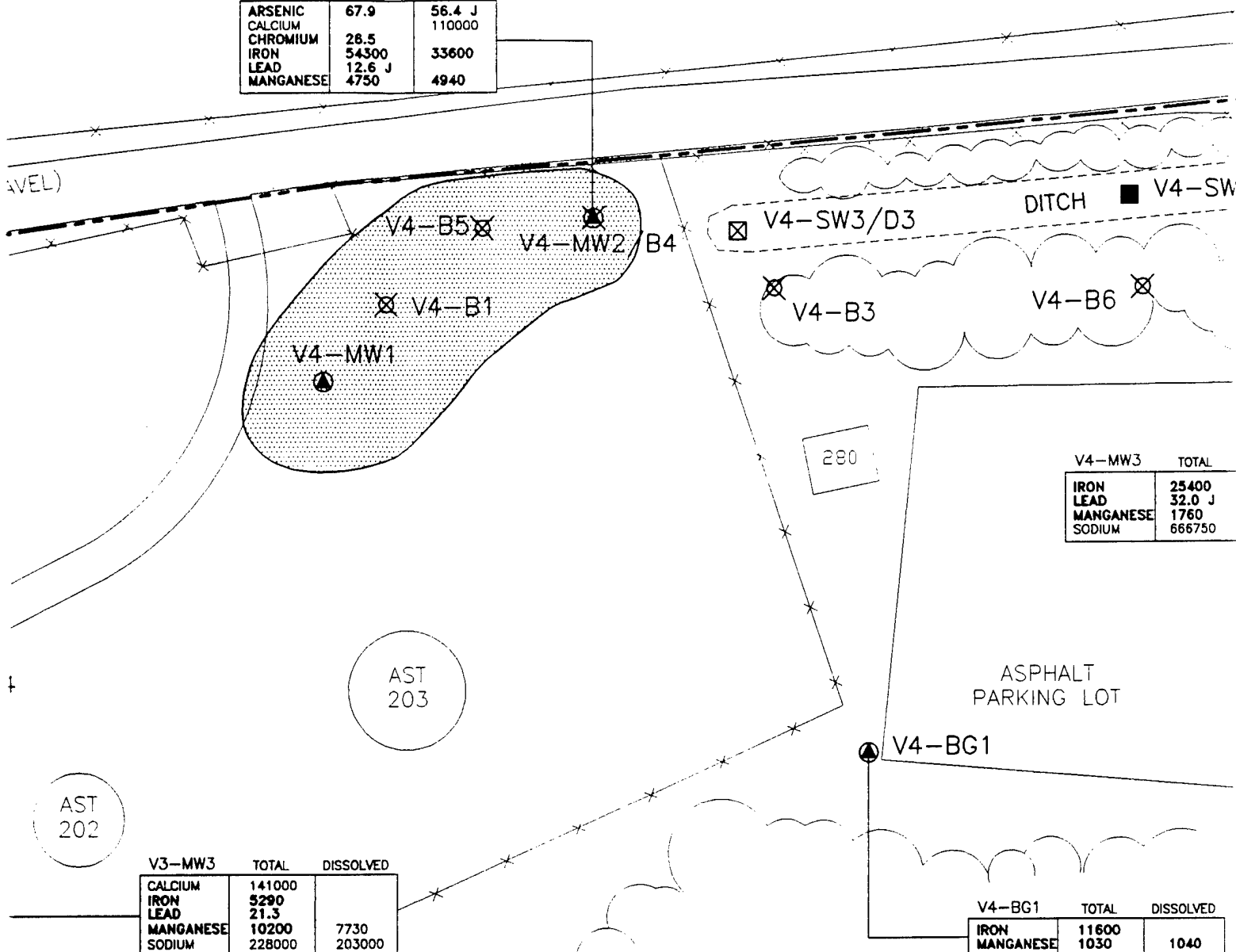
Sample location - D indicates duplicate sample.

() Result is below the CRDL.

J Reported value is estimated.



V4-MW2	TOTAL	DISSOLVED
ARSENIC	67.9	56.4 J
CALCIUM		110000
CHROMIUM	28.5	
IRON	54300	33600
LEAD	12.6 J	
MANGANESE	4750	4940



V4-MW3	TOTAL
IRON	25400
LEAD	32.0 J
MANGANESE	1760
SODIUM	666750

V3-MW3	TOTAL	DISSOLVED
CALCIUM	141000	
IRON	5290	
LEAD	21.3	
MANGANESE	10200	7730
SODIUM	228000	203000

V4-BG1	TOTAL	DISSOLVED
IRON	11600	
MANGANESE	1030	1040

ALL SAMPLES ANALYZED BY ENVIRONMENTAL PROTECTION AGENCY (EPA) CONTRACT LABORATORY PROGRAM (CLP) METHODS, 3/90 REVISION, FOR TARGET ANALYTE LIST (TAL) METALS (TOTAL AND DISSOLVED)

ALL CONCENTRATIONS IN MICROGRAMS/LITER (ug/l) OR PARTS PER BILLION (ppb)

NO ENTRY INDICATES NO DETECTION OR NO SIGNIFICANT DETECTION, IN EXCESS OF THE BACKGROUND CONCENTRATION AND/OR STATE OF VERMONT 1988 GROUNDWATER QUALITY STANDARDS (IF AVAILABLE).

TOTAL OR DISSOLVED/D INDICATES DUPLICATE SAMPLE ALSO ANALYZED (HIGHEST OF TWO RESULTS ARE PRESENTED)

() RESULT IS BELOW THE CONTRACT REQUIRED DETECTION LIMIT

J RESULT IS ESTIMATED

5290 DETECTION EXCEEDS 1988 GROUNDWATER QUALITY STANDARD



APPROXIMATE AREA OF DISSOLVED-PHASE GROUNDWATER CONTAMINATION: VOLATILE ORGANIC COMPOUNDS IN EXCESS OF 1988 STATE OF VERMONT GROUNDWATER QUALITY STANDARDS

APPLICABLE BASE-WIDE BACKGROUND VALUES FOR GROUNDWATER (ug/L) AND STATE OF VERMONT 1988 GROUNDWATER QUALITY STANDARDS (ug/L)

TAL METAL	BACKGROUND CONCENTRATION	VERMONT STANDARDS
ARSENIC	39.7	50/25
CALCIUM	109000	-
CHROMIUM	108	50/25
IRON	103,000	300/150
LEAD	39.9	20/10
MAGNESIUM	29,700	-
MANGANESE	3,770	50/25
SODIUM	109000	-

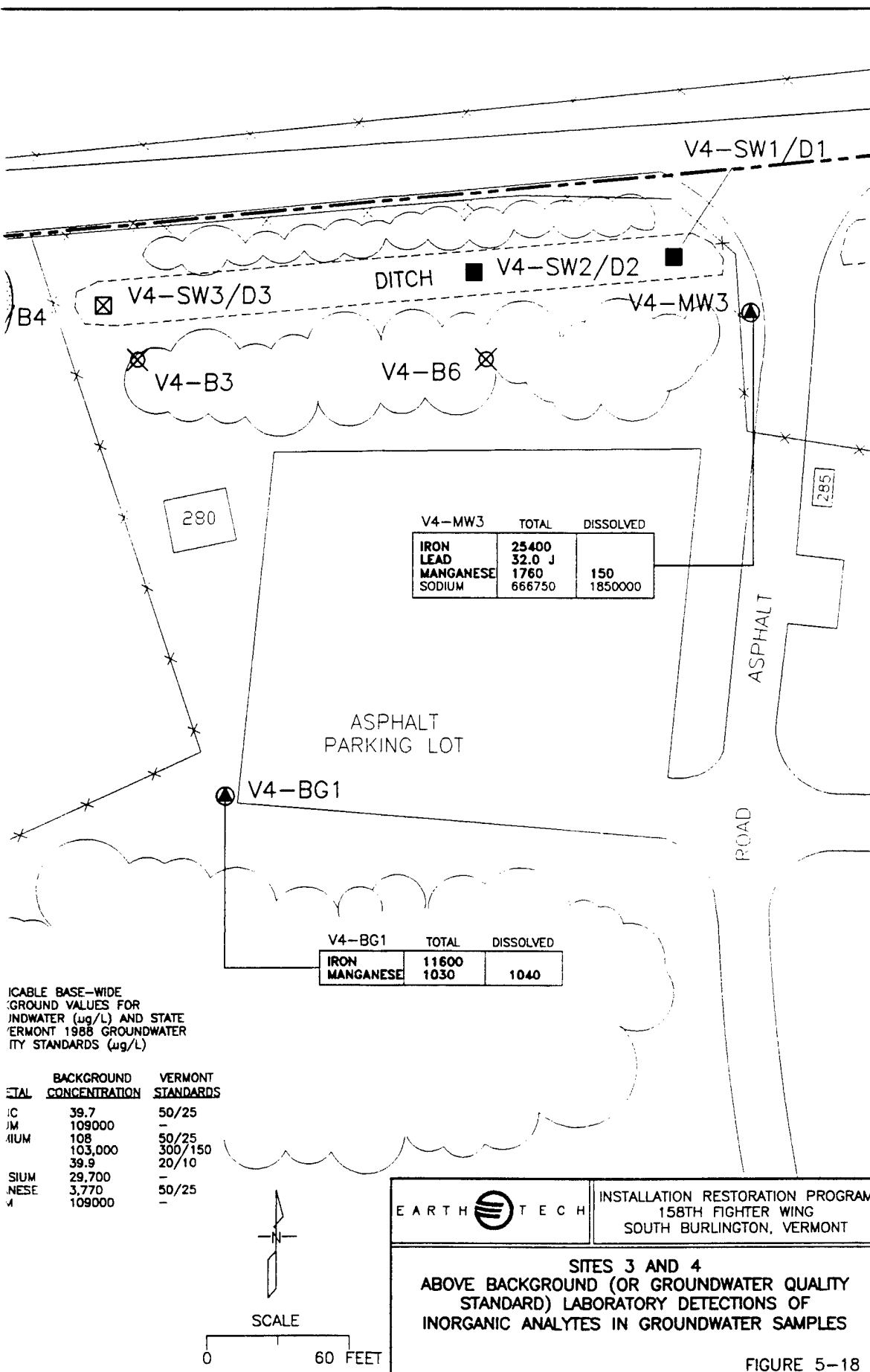


SCALE

0 60 FEET

EARTH  TEC

ABOVE BACKGROU
STANDARD) L/
INORGANIC ANALY



in groundwater from background and Site 3 and Site 4 monitoring wells, which equaled or exceeded State of Vermont Groundwater Quality Standards, are presented in the following discussion.

Detections of total TAL metals above background values in groundwater from Site 3 background monitoring well V3-BG1, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to iron (9,810 ppb) and manganese (553 ppb). The detections exceeded respective SESs. Dissolved TAL metal results indicated no detection of iron and a lower concentration of manganese (82 ppb).

Detections of total TAL metals above background values were indicated in groundwater from both Site 3 monitoring wells (V3-MW1 and V3-MW3). Significant detections of total TAL metals in groundwater from well V3-MW1, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to lead (25.1 ppb), iron (7560 ppb), and manganese (7,340 ppb). The concentrations exceeded the respective PES and SESs. Dissolved TAL metal results indicated a lower concentration of manganese (2,840 ppb), still in excess of the SES, and no detection of iron and lead. Significant detections of total TAL metals in groundwater from well V3-MW3, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to lead (21.3 ppb), iron (5,290 ppb), and manganese (10,200 ppb). The concentrations exceeded the respective PES and SESs. Dissolved TAL metal results indicated no detections of iron and lead, and a lower concentration of manganese (7,730 ppb), still in excess of the SES.

Detections of total TAL metals above background values in groundwater from Site 4 background monitoring well V4-BG1, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to iron (11,600 ppb) and manganese (1,030 ppb). The detections exceeded respective SESs. Dissolved TAL metal results indicated no detection of iron, and a comparable concentration of manganese (1,040 ppb).

Detections of total TAL metals above background values were indicated in groundwater from both Site 4 monitoring wells (V4-MW2 and V4-MW3). Detections of total TAL metals in groundwater from well V4-MW2, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to arsenic (67.9 ppb), chromium (26.5 ppb) iron (54,300 ppb) and manganese (4,750 ppb). These concentrations exceeded respective Groundwater Quality Standards (PESs and PPAL for chromium). Dissolved TAL metal results indicated, lower concentrations of arsenic (56.4 J ppb) and iron (33,600 ppb), and a higher concentration of manganese (4940 ppb) all in excess of the respective PES and SESs. The dissolved concentrations for arsenic, iron, and manganese also exceeded the respective PES and SESs. Significant detections of total TAL metals in groundwater from well V4-MW3, which equaled or exceeded State of Vermont Groundwater Quality Standards, were limited to lead (32 J ppb), iron (25,400 ppb), and manganese (1,760 ppb). These concentrations equaled the respective PES and SESs. Dissolved TAL metals results indicated no detections of lead, iron, and manganese.

5.2.5 Laboratory Analytical Results - Surface Water and Sediments

Excluding QA/QC samples, one surface water sample and three surface sediment samples were collected from the open drainage ditch in the eastern portion of Site 4, and submitted

for laboratory analysis for VOCs, SVOCs, TPH, and TAL metals. Surface water was present in only the westernmost portion of the drainage ditch, therefore, only one sample was collected; location V4-SW3 (Figure 5-1). Three surface sediment locations were sampled; V4-D1, V4-D2, and V4-D3 (Figure 5-1). Location V4-SW3/D3 is closest to the suspected source area in the western portion of the site. Conversely, location V4-D1 is located in the easternmost portion of the drainage ditch, farthest from the suspected source area.

Detections of organic analytes (VOCs, SVOCs, and TPH) per sampling location (surface water and sediments) are presented in Tables 5-8 (surface water) and 5-9 (sediments), and in Figure 5-19. Detections of inorganic analytes (TAL metals) per surface water and sediment sampling location are presented in Tables 5-10 (surface water) and 5-11 (surface sediments), and on Figure 5-20. State of Vermont ARARs for contaminants in base-specific storm drainage and related surface sediments are not available for comparison. Complete listings of analytes and laboratory analytical results are presented in Appendix J.

5.2.5.1 Organics - Surface Water and Sediments

Organics in surface water and sediment samples from Site 4 are summarized in the following discussions of laboratory analytical detections of VOCs, SVOCs, and TPH.

VOCs

Laboratory analyses for VOCs in surface water and sediment samples were conducted according to EPA SW-846 Methods 8010/8020 (EPA 1986). VOCs analyses included analysis for aromatic VOCs (Method 8010) and for halogenated VOCs (Method 8020). Analysis for dichlorobenzene was included under both Methods 8010 and 8020 for surface water and sediments, and under the CLP 3/90 analyses for SVOCs in surface sediments. Detection of dichlorobenzene was suspect, as it was limited to one Method 8020 detection for the surface water sample. Dichlorobenzenes were not included in SVOC analyses under CLP 10/92 for waters, but were included under CLP 3/90 analyses for sediments. Detections of VOCs in surface water and sediment samples, reported in $\mu\text{g}/\ell$ or ppb for water and $\mu\text{g}/\text{kg}$ or ppb for sediments, are summarized in Tables 5-8 (surface water) and 5-9 (surface sediments), and in Figure 5-19.

Detections of VOCs in surface water from Site 4 location V4-SW3 were limited to low concentrations (less than 1 ppb) of 1,2-dichlorobenzene (0.35 J ppb), and 1,3-dimethylbenzene (0.34 J and 0.53 ppb) (equivalent to total xylenes). Detections of VOCs in surface sediments were limited to one low (less than 100 ppb) detection of methylene chloride (67 J ppb) from location V4-D2.

SVOCs

Laboratory analyses for SVOCs in surface water and sediment samples were conducted according to EPA CLP Methods, 10/92 Revision for water and 3/90 Revision for sediments (EPA 1992 and EPA 1990a). CLP 3/90 analyses for SVOCs in sediments included dichlorobenzenes. Detections of SVOCs in surface water and sediment samples, reported in $\mu\text{g}/\ell$ or ppb for water and $\mu\text{g}/\text{kg}$ or ppb for sediments, are summarized in Tables 5-8 (surface water) and 5-9 (surface sediments), and in Figure 5-19.

Table 5-8 Laboratory Detections of Organic Compounds in Surface Water Samples
Vermont Air National Guard Base

Area Location		Site 4 Drainage Ditch	
Sample Location		V4-SW3	V4-SW3-D
Date Sampled Material Type		10/28/94	Surface Water
VOCs ¹ (µg/l) (a)	PQL		
1,2-Dichlorobenzene	0.15	0.35 J	0.30 B
1,3-Dimethylbenzene	0.20	0.34 J	0.53
Total Xylenes		0.34	0.53
VOCs ¹ Dilution Factor		1	1
SVOCs ² (µg/l) (a)	CRQL		
bis (2-Ethylhexyl) phthalate	5	7	8
Di-n-butyl phthalate	5	0.6 J ()	
Phenol	5	0.6 J ()	
SVOCs ² Dilution Factor		1	1
TPH ³ (mg/l) (a)	PQL		
Diesel	0.5	12	16 J
Gasoline	0.01	0.43 ()	0.50
TPH ³ Dilution Factor		1	1

¹ VOCs - Volatile Organic Compounds - analyzed by U.S. Environmental Protection Agency (EPA) SW-846 Methods 8010/8020. Analyses for dichlorobenzenes were included under both Methods 8010 (Halogenated) and 8020 (Aromatic). Detections were limited to Method 8020 analyses. Xylenes are listed as dimethylbenzenes; 1,2-dimethylbenzene = ortho-xylene; 1,3-dimethylbenzene = meta-xylene; 1,4-dimethylbenzene = para-xylene. All concentrations in micrograms/liter (µg/l) or parts per billion (ppb).

² SVOCs - Semivolatile Organic Compounds - analyzed by EPA Contract Laboratory Program (CLP) Methods (10/92). All concentrations in µg/l or ppb.

³ TPH - Total Petroleum Hydrocarbons - analyzed by California Modified Method 8015. All concentrations in milligrams/liter (mg/l) or parts per million (ppm).

(a) No entry indicates no detection.

CRQL Contract Required Quantitation Limit.

PQL Practical Quantitation Limit.

Sample Location - D indicates duplicate sample.

() Result is below PQL or CRQL.

J Results is estimated.

Table 5-9 Laboratory Detections of Organic Compounds in Surface Sediment Samples
Vermont Air National Guard Base

Area Location		Site 4 Drainage Ditch			
Sample Location		V4-D1		V4-D2	V4-D3
Sample Depth (ft bgs) Date Sampled Material Type		0 - 0.5 10/28/94 Sand/Silt	0 - 0.5 D	0 - 0.5 10/28/94 Sand/ Silt	0 - 0.5 10/28/94 Sand
Moisture Content %		18	15	31	9
VOCs ¹ (µg/kg) (a)	PQL				
Ethylbenzene	1.8				
1,2-Dichlorobenzene	1.4				
1,3-Dimethylbenzene	3.2				
1,4-Dimethylbenzene	3.2				
Total Xylenes					
Methylene Chloride	3.1			67	
Toluene	5.3				
VOCs ¹ Dilution Factor		1	1	1/D 5	1
SVOCs ² (µg/kg) (a)	CRQL				
Acenaphthene	330			3500 J	
Anthracene	330			2500	
Benzo (a) anthracene	330			5300	46 ()
bis (2-Ethylhexyl) phthalate	330			1100 ()	170 ()
Benzo (b) fluoranthene	330			7000	82 ()
Benzo (k) fluoranthene	330			7500	81 ()
Benzo (a) pyrene	330			4500	
Benzo (g,h,i) perylene	330			2800	
Butyl benzyl phthalate	330		400 () J	600 () J	
Carbazole	330			1900 ()	
Chrysene	330			5300	46 ()

Table 5-9 Laboratory Detections of Organic Compounds in Surface Sediment Samples
Vermont Air National Guard Base

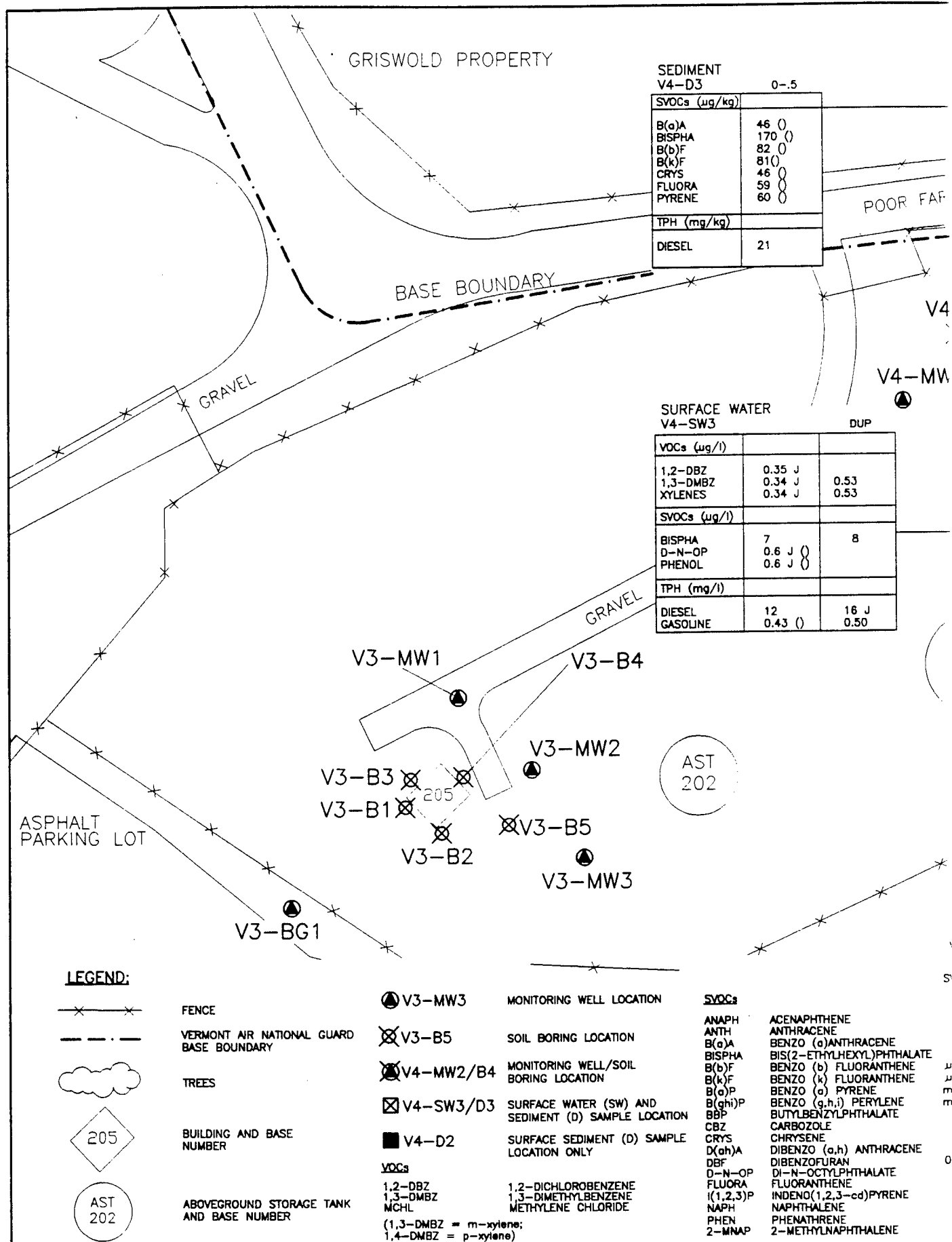
Area Location		Site 4 Drainage Ditch			
Sample Location		V4-D1		V4-D2	V4-D3
Sample Depth (ft bgs)	Date Sampled	0 - 0.5	0 - 0.5 D	0 - 0.5	0 - 0.5
Material Type		10/28/94 Sand/Silt		10/28/94 Sand/ Silt	10/28/94 Sand
Moisture Content %		18	15	31	9
Dibenzo (a,h) anthracene	330			880 ()	
Dibenzofuran	330			1800 ()	
Di-n-octylphthalate	330		430 J ()		
Fluoranthene	330			14000	59 ()
Fluorene	330			2700	
Indeno (1,2,3-cd) pyrene	330			2900	
2-Methylnaphthalene	330			2400	
Naphthalene	330			630 ()	
Phenathrene	330			16000	
Pyrene	330			11000	60 ()
SVOCs ² Dilution Factor		10	10	5	10
TPH ³ (mg/kg) (a)	POL				
Diesel	9.8	240	57	240	21
Gasoline	0.5	0.032 B	0.047 B	0.049 B	0.051 B
TPH ³ Dilution Factor		1	1	1	1

1 VOCs - Volatile Organic Compounds - analyzed by U.S. Environmental Protection Agency (EPA) SW-846 Methods 8010/8020. (Halogenated)/8020 (Aromatic) are indicated.
Xylenes are listed as dimethylbenzenes; 1,2-dimethylbenzene = ortho-xylene; 1,3-dimethylbenzene = meta-xylene; 1,4-dimethylbenzene = para-xylene. All concentrations in micrograms/kilogram (µg/kg) or parts per billion (ppb).
2 SVOCs - Semivolatile Organic Compounds - analyzed by EPA Contract Laboratory Method (CLP) Method (3/90). All concentrations in µg/kg or ppb.
3 TPH - Total Petroleum Hydrocarbons - analyzed by California Modified Method 8015. All concentrations in milligrams/kilogram or parts per million (ppm).

(a) No entry indicates no detection.

CRQL (CRQL or POL)* Dilution factor/(100 - % moisture)/100).
Use the following equation to calculate the CRQL or POL for each individual sample:

Sample Depth: ft - feet, bgs - below ground surface, and D duplicate sample.
() Result is below the sample - specific POL or CRQL.
J Result is estimated.

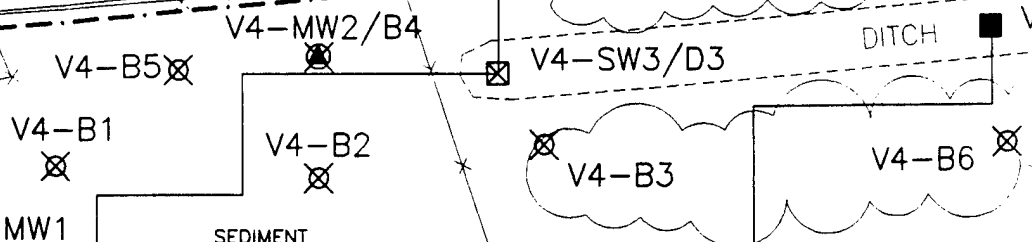


SEDIMENT V4-D3

0-.5

SVOCs (ug/kg)	
B(a)A	46 ()
BISPHA	170 ()
B(b)F	82 ()
B(k)F	81()
CRYA	46 ()
FLUORA	59 ()
PYRENE	60 ()
TPH (mg/kg)	
DIESEL	21

POOR FARM ROAD (GRAVEL)



SURFACE WATER V4-SW3

DUP

VOCs (ug/l)		
1,2-DBZ	0.35 J	
1,3-DMBZ	0.34 J	0.53
XYLENES	0.34 J	0.53
SVOCs (ug/l)		
BISPHA	7	8
D-N-OP	0.6 J ()	
PHENOL	0.6 J ()	
TPH (mg/l)		
DIESEL	12	16 J
GASOLINE	0.43 ()	0.50

SEDIMENT V4-D2

0-.5

VOCs (ug/kg)	
MCHL	67 J
SVOCs (ug/kg)	
ANAPH	3500 J
ANTH	2500
B(a)A	5300
BISPHA	1100
B(b)F	7000
B(k)F	7500
B(a)P	4500
B(ghi)P	2800
BBP	600
CBZ	1900
CRYA	5300
D(a,h)A	880
DBF	1800
FLUORA	14000
FLUORENE	2700
I(1,2,3)P	2900
NAPH	630
2-MNAP	2400
PHEN	16000
PYRENE	11000
TPH (mg/kg)	
DIESEL	240

SEDIMENT V4-D1

0-

SVOCs (ug/kg)	
BBP	400
D-N-OP	430
TPH (mg/kg)	
DIESEL	24

280

ASPHALT
PARKING LOT

V4-BG1

V3-B4

AST
203

MW2

AST
202

5

1
-MW3

WELL LOCATION

SVOCs

LOCATION
WELL/SOIL
ATION
TER (SW) AND
SAMPLE LOCATION
DIMENT (D) SAMPLE
ILY

ANAPH
ANTH
B(a)A
BISPHA
B(b)F
B(k)F
B(a)P
B(ghi)P
BBP
CBZ
CRYA
D(a,h)A
DBF
D-N-OP
FLUORA
I(1,2,3)P
NAPH
PHEN
2-MNAP
ACENAPHTHENE
ANTHRACENE
BENZO (a)ANTHRACENE
BIS(2-ETHYLHEXYL)PHTHALATE
BENZO (b) FLUORANTHENE
BENZO (k) FLUORANTHENE
BENZO (a) PYRENE
BENZO (g,h,i) PERYLENE
BUTYLBENZYLPHTHALATE
CARBOZOLE
CHRYSENE
DIBENZO (a,h) ANTHRACENE
DIBENZOFURAN
DI-N-OCTYLPHTHALATE
FLUORANTHENE
INDENO(1,2,3-cd)PYRENE
NAPHTHALENE
PHENANTHRENE
2-METHYLNAPHTHALENE

VOCs

SVOCs

TPH

ug/l
ug/kg
mg/l
mg/kg

DUP
0-.5/D

()
J

VOLATILE ORGANIC COMPOUNDS
SAMPLES ANALYZED BY ENVIRONMENTAL PROTECTION
AGENCY (EPA) SW-846 METHODS 8010/8020
SEMIVOLATILE ORGANIC COMPOUNDS
ANALYZED BY ENVIRONMENTAL PROTECTION AGENCY (EPA)
CONTRACT LABORATORY PROGRAM (CLP) METHODS,
3/90 REVISION - SEDIMENTS
10/92 REVISION - WATER
TOTAL PETROLEUM HYDROCARBONS
ANALYZED BY CALIFORNIA MODIFIED METHOD 8015

MICROGRAMS PER LITER OR PARTS PER BILLION (ppb)
MICROGRAMS PER KILOGRAM OR PARTS PER BILLION (ppb)
MILLIGRAMS PER LITER OR PARTS PER MILLION (ppm)
MILLIGRAMS PER KILOGRAM OR PARTS PER MILLION (ppm)

NO ENTRY INDICATES NO DETECTION.

DUPLICATE SAMPLE

SAMPLE DEPTH, INTERVAL IN FEET

D INDICATES DUPLICATE SAMPLE ALSO ANALYZED

(HIGHEST OF TWO RESULTS ARE PRESENTED)

RESULT BELOW SAMPLE-SPECIFIC PRACTICAL QUANTITATION

LIMIT OR CONTRACT REQUIRED QUANTITATION LIMIT

RESULT IS ESTIMATED

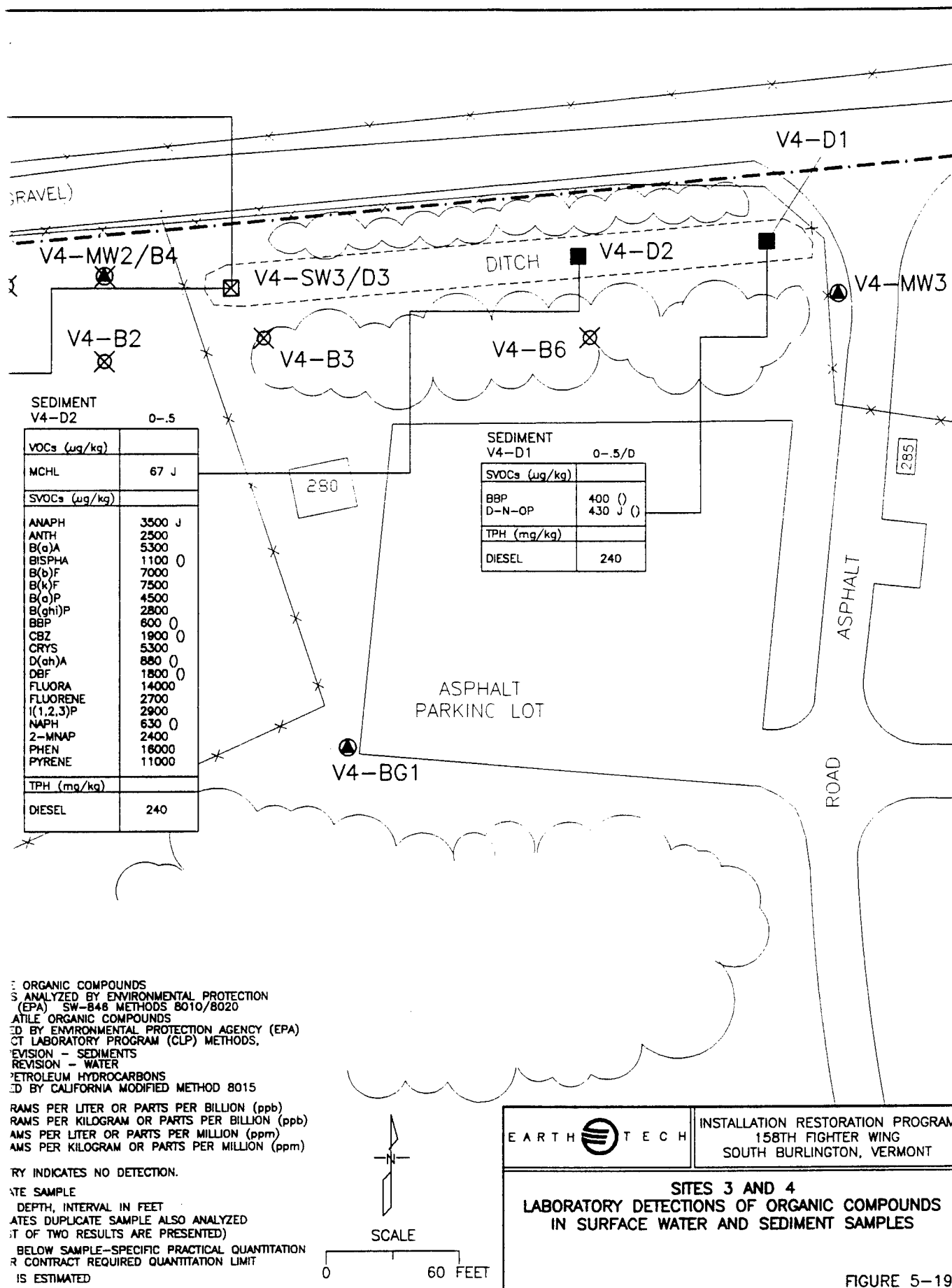


SCALE

0 60 FEET

EARTH

LABORATOR
IN SURI



**Table 5-10 Laboratory Detections of Inorganic Analytes in Surface Water Samples
Vermont Air National Guard Base**

Area Location		Site 4 Drainage Ditch	
Sample Location		V4-SW3	V4-SW3-D
Date Sampled Material Type		10/28/94 Surface Water	
TAL ¹ Metals (µg/l)(a)	CRQL		
Aluminum	200	156 (I)	144 (I)
Arsenic	10	2.4 J (I)	1.9 J (I)
Barium	200	18.7 (I)	18.0 (I)
Calcium	500	18900	18300
Copper	25	11.5 (I)	10.4 (I)
Iron	10	1320	1200
Lead	3	11.0	907
Magnesium	5000		1480 (I)
Manganese	15	121	116
Potassium	2.00	6650	6420
Sodium	5000	15000	14600
Zinc	20	2470 J	2350 J
TAL ¹ Metals Dilution Factor		1	1

¹ TAL Metals - Target Analyte List Metals - analyzed U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3/80). All concentrations in micrograms/liter (µg/l) or parts per billion (ppb).
(a) No entry indicates no detection.

CRQL Contract Required Detection Limit
Sample Location - D indicates duplicate sample.

(I) Result is below the CRQL.
J Result is estimated

**Table 5-11 Laboratory Detections of Inorganic Analytes in Surface Sediment Samples
Vermont Air National Guard Base**

Area Location		Site 4 Drainage Ditch			
Sample Location		V4-D1		V4-D2	V4-D3
Sample Depth (ft bgs) Date Sampled	Material Type	0 - 0.5 10/28/94 Sand/Silt	0 - 0.5 D	0 - 0.5 10/28/94 Sand/Silt	0 - 0.5 10/28/94 Sand
Moisture Content %		17.9	15.1	30.7	9.2
TAL ¹ Metals (mg/kg) (a)		CRDL			
Aluminum		4880	6010	8130	3410
Barium		22.7 ()	26.2 ()	54.0 ()	9.2 ()
Cadmium		1.5 J	1.9 J	3.8 J	
Calcium		1390 J	3410 J	8560 J	706 J ()
Chromium		48.3	49.7 J	37.7	6.3
Cobalt		6.0 ()	4.2 ()	12.4 ()	3.3 ()
Copper		22.6	24.2	33.4	6.6
Iron		10700	12500	16500	7790
Lead		84.2 J	128 J	113 J	
Magnesium		2920	4080	3010	1430
Manganese		157 J	131 J	607 J	184 J
Mercury		0.1		0.17 J	
Nickel		21.0	10.8	21.7	
Silver		1.5 ()	1.0 ()	1.4 ()	
Vanadium		11.0 ()	12.3	16.8	5.1 ()
Zinc		153	170	400	58.3
TAL ¹ Metals Dilution Factor		1	1	1	1

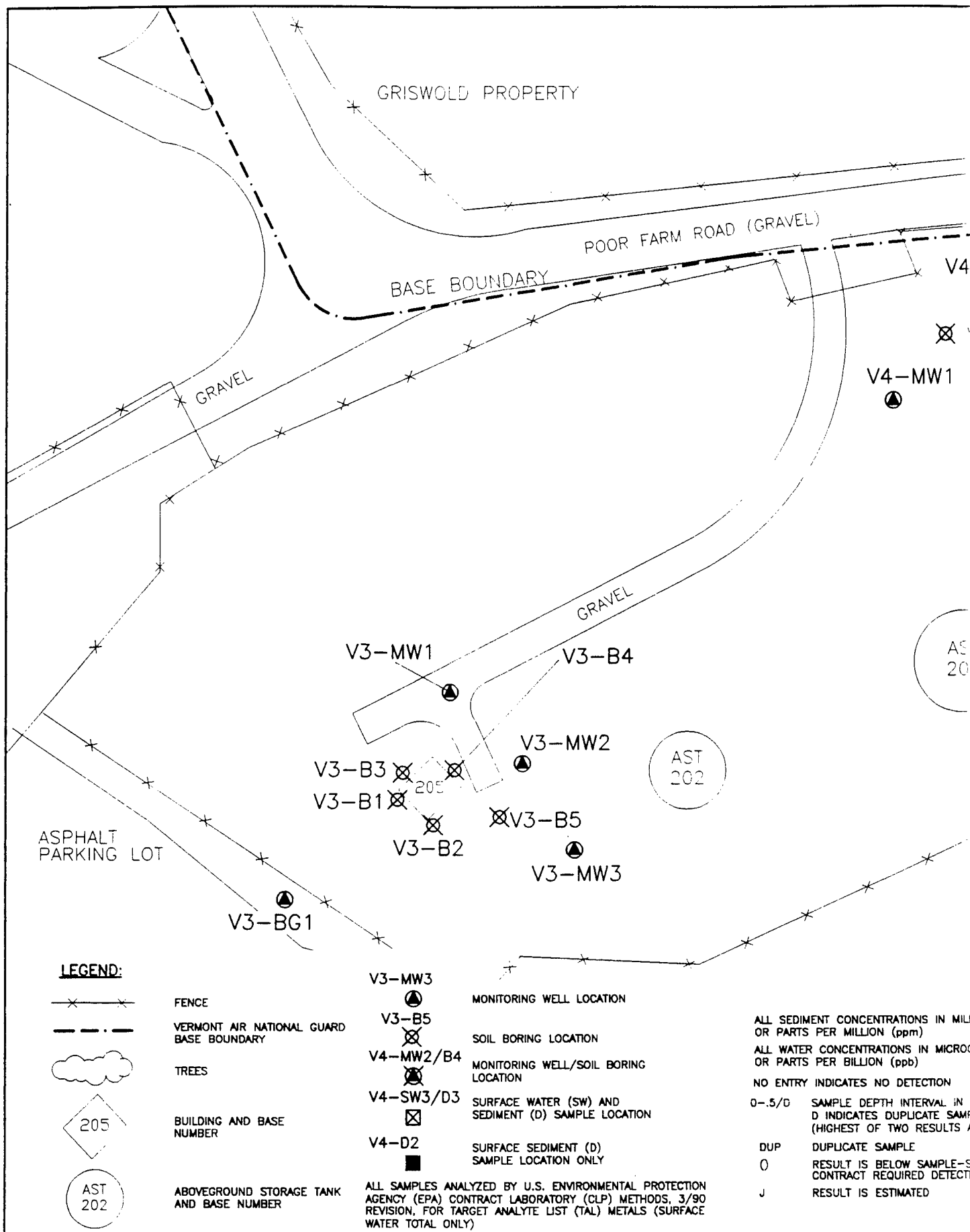
¹ TAL Metals Target Analyte List Metals - analyzed by U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Methods (3/90). All concentrations in milligrams/kilogram (mg/kg) or parts per million (ppm).

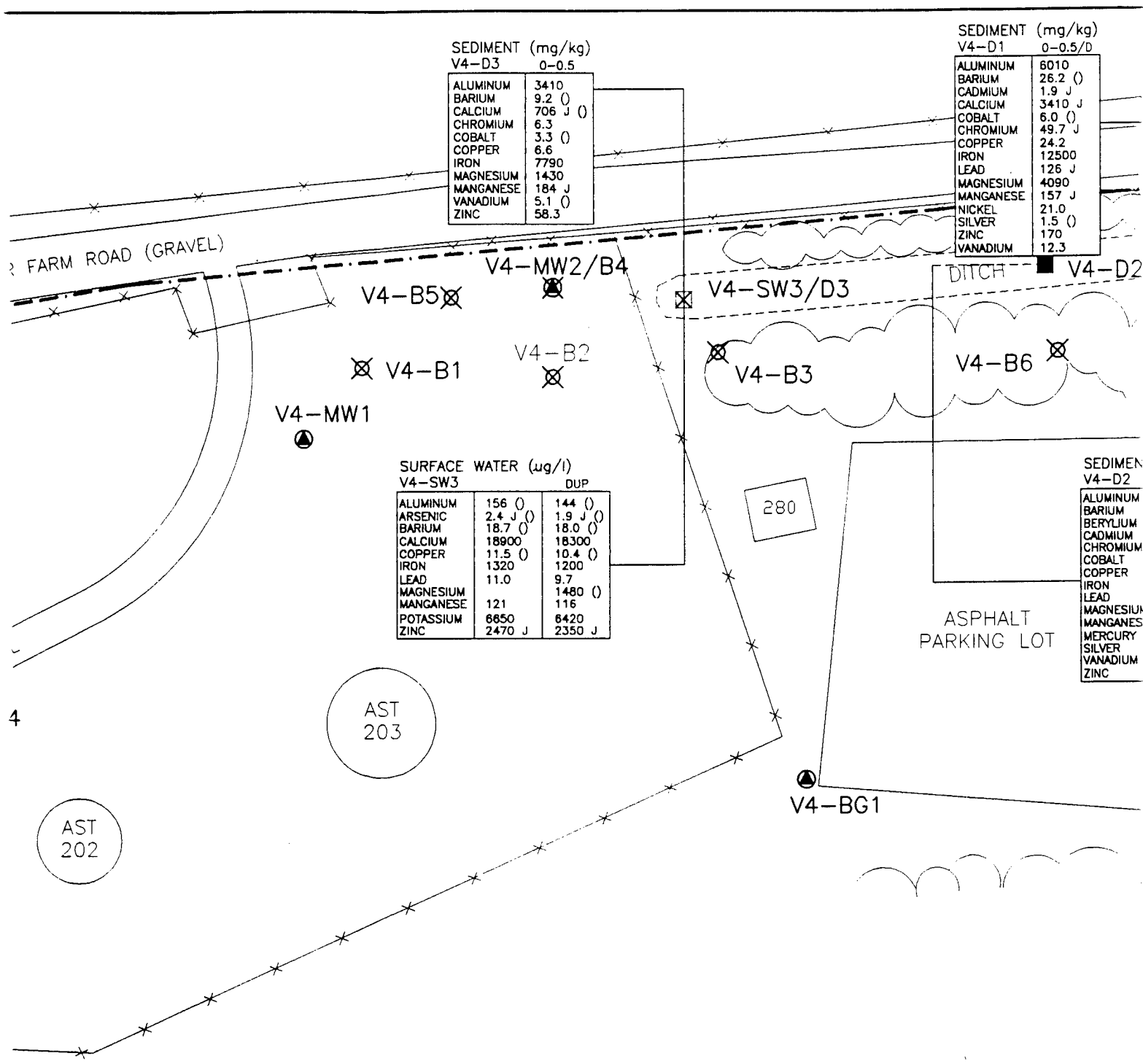
(a) No entry indicates no detection.
CRDL - Contract Required Detection Limit. Values for CRDL represent only low soil matrix. Use the following equation to calculate the CRDL for each individual sample: $CRDL = [Dilution\ factor / (100 - \% moisture) / 100]$.

Sample Depth: ft-feet, bgs-below ground surface, and D indicates duplicate sample.

() Result is below the sample-specific CRDL.

J Result is estimated.





SEDIMENT (mg/kg)
V4-D3 0-0.5

ALUMINUM	3410
BARIIUM	9.2 ()
CALCIUM	706 J ()
CHROMIUM	6.3
COBALT	3.3 ()
COPPER	6.6
IRON	7790
MAGNESIUM	1430
MANGANESE	184 J
VANADIUM	5.1 ()
ZINC	58.3

SEDIMENT (mg/kg)
V4-D1 0-0.5/D

ALUMINUM	6010
BARIIUM	26.2 ()
CADMIUM	1.9 J
CALCIUM	3410 J
COBALT	6.0 ()
CHROMIUM	49.7 J
COPPER	24.2
IRON	12500
LEAD	126 J
MAGNESIUM	4090
MANGANESE	157 J
NICKEL	21.0
SILVER	1.5 ()
ZINC	170
VANADIUM	12.3

SURFACE WATER (ug/l)

V4-SW3		DUP
ALUMINUM	156 ()	144 ()
ARSENIC	2.4 J ()	1.9 J ()
BARIIUM	18.7 ()	18.0 ()
CALCIUM	18900	18300
COPPER	11.5 ()	10.4 ()
IRON	1320	1200
LEAD	11.0	9.7
MAGNESIUM		1480 ()
MANGANESE	121	116
POTASSIUM	6650	6420
ZINC	2470 J	2350 J

SEDIMENT
V4-D2

ALUMINUM	
BARIIUM	
BERYLLIUM	
CADMIUM	
CHROMIUM	
COBALT	
COPPER	
IRON	
LEAD	
MAGNESIUM	
MANGANESE	
MERCURY	
SILVER	
VANADIUM	
ZINC	

ALL SEDIMENT CONCENTRATIONS IN MILLIGRAMS/KILOGRAM (mg/kg)
OR PARTS PER MILLION (ppm)

ALL WATER CONCENTRATIONS IN MICROGRAMS/LITER (ug/L)
OR PARTS PER BILLION (ppb)

NO ENTRY INDICATES NO DETECTION

0-.5/D SAMPLE DEPTH INTERVAL IN FEET
D INDICATES DUPLICATE SAMPLE ALSO ANALYZED
(HIGHEST OF TWO RESULTS ARE PRESENTED)

DUP DUPLICATE SAMPLE
() RESULT IS BELOW SAMPLE-SPECIFIC
CONTRACT REQUIRED DETECTION LIMIT
J RESULT IS ESTIMATED

AL PROTECTION
METHODS, 3/90
TALS (SURFACE

EARTH  TEC

LABORATORY DETE
IN SURFACE W

SCALE

0 60 FEET

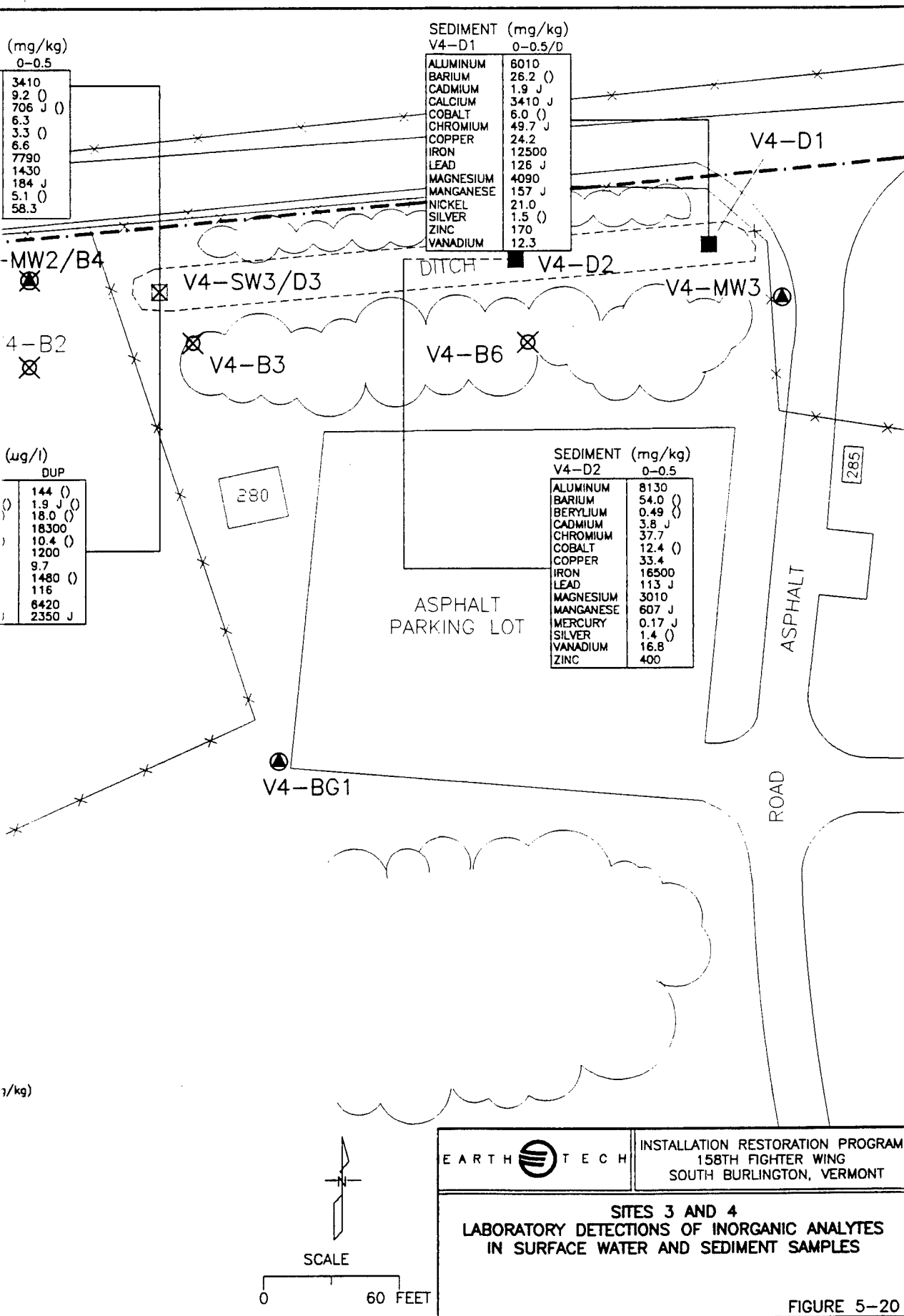


FIGURE 5-20

Detections of SVOCs in surface water from Site 4 location V4-SW3 were limited to low concentrations of (near or below CRQLs) bis-(2-ethylhexyl) phthalate (7 and 8 ppb) di-n-octylphthalate (0.6 J () ppb), and phenol (0.6 J () ppb). Detections of SVOCs in sediment samples from Site 4 locations ranged from low (near or below CRQLs) to higher concentrations (above CRQLs). Detections in the westernmost sample location V4-D3 were limited to low concentrations (below CRQLs) of benzo(a)anthracene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluorene, and pyrene. Similarly, only low concentrations (below CRQLs) of butylbenzylphthalate and di-n-octylphthalate were indicated in sample V4-D1, from the easternmost portion of the ditch. Low to high concentrations of SVOCs were indicated in sample V4-D2, from the mid-portion of the ditch. Low concentration detections (below CRQLs) included bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carbazole, dibenzo(a,h)anthracene, dibenzofuran, and naphthalene. Higher concentrations (above of CRQLs) included acenaphthene (3,500 J ppb), anthracene (2,500 ppb), benzo(a)anthracene (5,300 ppb), benzo(b)fluoranthene (7,000 ppb), benzo(k)fluoranthene (7,500 ppb), benzo(a)pyrene (4,500 ppb), benzo(g,h,i)perylene (2,800 ppb), chrysene (5,300 ppb), fluoranthene (14,000 ppb), fluorene (2,700 ppb), indeno(1,2,3-cd)pyrene (2,900 ppb), 2-methylnaphthalene (2,400 ppb), phenanthrene (16,000 ppb), and pyrene (11,000 ppb).

TPH

Laboratory analyses for TPH in surface water and sediment samples were conducted according to California Modified Method 8015 (California 1988). Detections of TPH (diesel and gasoline) in surface water and sediment samples, reported in mg/l or ppm for water and mg/kg or ppm for sediments, are summarized in Tables 5-8 (surface water) and 5-9 (surface sediments), and in Figure 5-19.

Detections of TPH in surface water from Site 4 location V4-SW3 consisted of low (below the PQL and/or less than 1 ppm) concentrations of gasoline (0.43 () and 0.50 ppm), and higher concentrations of diesel (12 and 16 J ppm). Detections of TPH in sediment samples from Site 4 locations ranged from no concentrations of gasoline to high concentrations (in excess of 100 ppm) of diesel. Diesel detections were highest (240 ppm) in locations V4-D2 and V4-D1 in the middle and easternmost portions of the ditch, respectively. Detections in sample location V4-D3 consisted of a comparatively low detection (less than 100 ppm) of diesel (21 ppm).

5.2.5.2 Inorganics - Surface Water and Sediments

Laboratory analyses for TAL metals in surface water (total sample only) and sediment samples were conducted according to EPA CLP Methods, 3/90 Revision (EPA 1990b). Inorganics in surface water and sediment samples from Site 4 are summarized in the following discussions of laboratory analytical detections of TAL metals.

Three TAL metals were not detected in both surface water and sediment samples; antimony, selenium, and thallium. These metals were also not detected in soil and/or groundwater samples. Non-detected TAL metals in surface water samples also included beryllium, cadmium, chromium, cobalt, mercury, nickel, silver, and vanadium. Non-detected TAL metals in surface sediment samples also included arsenic. Trace detections of mercury and silver

were indicated in sediment samples, but were not detected in any other ASI environmental sample.

Detections of TAL metals in surface water and sediment samples, reported in $\mu\text{g}/\ell$ or ppb for water and mg/kg or ppm for sediments, are summarized in Tables 5-10 (surface water) and 5-11 (surface sediments). Figure 5-20 presents all detections of TAL metals in surface water and sediment samples.

Detections of TAL metals in surface water from location V4-SW3 ranged from low (below CRDLs) to higher (above CRDLs) concentrations. Low detections (below CRDLs) included aluminum (156 () and 144 () ppb), arsenic (2.4 J () and 1.9 J () ppb), barium (18.7 () and 18 () ppb), copper (11.5 () and 10.4 () ppb), and magnesium (1480 () ppb). Higher detections (above CRDLs) included calcium (18,900 and 18,300 ppb), iron (1320 and 1200 ppb), lead (11 and 9.7 ppb), manganese (121 and 116 ppb), potassium (6650 and 6420 ppb), and zinc (2470 J and 2350 J ppb).

Detections of TAL metals in surface sediment samples (V4-D1, V4-D2, and V4-D3) from the Site 4 drainage ditch ranged from low (below CRDLs) to higher (above CRDLs) concentrations. The most and highest detections were indicated in sample V4-D2, from the mid-portion of the ditch. Low detections (below CRDLs) from all three locations included barium calcium, cobalt, silver, and vanadium. Higher detections (above CRDLs) from all three locations included aluminum (3,410 to 8,130 ppm), cadmium (1.9 J to 3.8 J ppm), calcium (1,390 J to 8,560 J ppm), chromium (6.3 to 49.7 J ppm), copper (6.6 to 33.4 ppm), iron (7,790 to 16,500 ppm), lead (113 J to 126 J ppm), magnesium (1,430 to 4,090 ppm), manganese (157 J to 607 J ppm), mercury (0.17 J ppm), nickel (21.0 to 21.7 ppm), vanadium (12.3 to 16.8 ppm), and zinc (58.3 to 400 ppm).

5.3 CONTAMINATION SUMMARY

Based on the results of field screening and confirmation activities, brief environmental contamination summaries for IRP Sites 3 and 4 are presented in the following sections. Table 5-12 summarizes boring/monitoring well locations which exhibited organic contaminants in subsurface soil and groundwater samples in excess of State of Vermont ARARs. Approximate areas of soil and groundwater contamination (detections in excess of ARARs) are presented in Figures 5-11 and 5-15, respectively.

Site 3 - Dry Well

Site 3 field screening and/or confirmation laboratory data indicate the presence of site related organic soil and groundwater contamination, and possibly site related inorganic groundwater contamination. Free-product was measured in one source area monitoring well.

**Table 5-12 Summary of Laboratory Analytical Detections of Organic Compounds in Subsurface Soil
and Groundwater Samples in Excess of State of Vermont Action Levels
Abbreviated Site Investigation - Installation Restoration Program Sites 3 and 4
Vermont Air National Guard Base**

Analyte	Vermont Enforcement Standard ^(a) Drinking Water	Vermont Primary Preventative Action Limit ^(a)	Vermont Residual Soil Value	Site 3				Site 4	
				V3-B3	V3-B4	V3-B5	V3-MW1	V4-B1	V4-B4/ V4-MW2
VOCs ^(a)	µg/l	µg/l	µg/kg	µg/kg	µg/kg*	µg/kg	µg/l	µg/kg	µg/l
Benzene	5	0.5	100		3700		160		82
Chlorobenzene	100	50	2000	5200	7900-18000	2700		15000	8000
1,2-Dichlorobenzene	620	310	12400		16000-30000			21000	22000
1,3-Dichlorobenzene	620	310	12400		20000				
1,4-Dichlorobenzene	75	7.5	1500	1600	3300-13000			3100	31000
Ethylbenzene	680	340	13600		18000-140000		420 D	50000	26000
Styrene	5	0.5	100	1200-5500	6300-40000	5500		32000	7500
Toluene	2420	1210	48400		170000- 180000				
Total Xylenes	400	200	8000	8400-10400	83000-52000	47600	1042	120000	95000

ARARs - Applicable or Relevant and Appropriate Requirements.

¹ 1988 State of Vermont Groundwater Quality Standards.

² 1992 State of Vermont Residual Soil Value (equal to 20 times respective Groundwater Quality Enforcement Standard).

(a) No entry indicates no detection in excess of Vermont ARARs. Note: Monitoring Wells V3-MW2 and V4-MW1 were not sampled due to the presence of free-product.

* Concentration range given when more than one value exceeds Vermont value.

mg/kg micrograms/kilogram

µg/l micrograms/liter

Site 4

Site 4 field screening and confirmation laboratory data indicate the presence of site related organic soil, groundwater, surface water, and surface sediment contamination, and possibly site related inorganic groundwater contamination. Free-product was measured in one source area monitoring well.

6.0 CONCLUSIONS

Conclusions for IRP Sites 3 and 4, based on the results of ASI field screening and confirmation activities, are presented in the following sections.

6.1 Background

Laboratory analytical results for subsurface soil and groundwater samples from single background locations in Site 3 and Site 4 indicated no organic or inorganic contamination. Groundwater concentrations of iron and manganese exceed State of Vermont Secondary Enforcement Standards in all SRI and ASI background wells, and in all Site 3 and Site 4 wells; however, these concentrations are not site related and are likely related to local geologic/hydrogeologic conditions.

6.2 Site 3 Contamination

Laboratory analytical results for subsurface soil and groundwater samples from Site 3 indicate the following site related contamination.

Organic soil contamination was indicated in Site 3 in the immediate vicinity (generally within 50 ft) of the dry well and transfer pump house (Building 205). Subsurface soil contamination was predominantly indicated in three of five soil borings, from depths ranging from shallow (3 to 5 ft bgs) to intermediate (8 to 15 ft bgs). The highest concentrations of organic contaminants were indicated proximal to the water table in the 13 to 15 ft sample interval in one boring. Significant soil contamination included: concentrations of VOCs in excess of State of Vermont Residual Soil Values (benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, styrene, toluene, and total xylenes), SVOCs in concentrations exceeding 1 part per million (ppm) (2-methynaphthalene, naphthalene, and bis(2-ethylhexyl)phthalate), and TPH in concentrations exceeding 1 ppm.

Organic, and possibly inorganic, groundwater contamination was indicated in Site 3, in an area immediately hydraulically downgradient of the dry well and the pump house (Building 205). Free-product (JP-4 fuel) was measured in one of three site monitoring wells, and that well was not sampled. Significant organic groundwater contamination was indicated in one of two site wells sampled, and included VOCs (benzene, ethylbenzene, and total xylenes) in excess of State of Vermont Groundwater Quality Standards and TPH in concentrations exceeding 1 ppm. Possible inorganic groundwater contamination was limited to detections of lead which exceeded the State of Vermont Groundwater Quality Standard in both site wells.

6.3 Site 4 Contamination

Laboratory analytical results for subsurface soil, groundwater, surface water, and surface sediment samples from Site 4 indicate the following site related contamination.

Soil

Organic soil contamination was indicated near the water table in the western portion of Site 4, in the vicinity (generally within 50 ft) of the initial sewer line excavation. Subsurface soil contamination was limited to sample depths near the water table (17 to 19 ft bgs) in three of six soil borings. The highest concentrations of organic contaminants were indicated in two borings located closest to the initial sewer line excavation. Significant soil contamination included concentrations of VOCs in excess of State of Vermont Residual Soil Values (benzene, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, styrene, and total xylenes), SVOCs in concentrations exceeding 1 ppm (methynaphthalene and naphthalene), and TPH in concentrations exceeding 1 ppm.

Groundwater

Organic, and possibly inorganic, groundwater contamination is present in Site 4. Free-product (JP-4 fuel) was detected in one of three site monitoring wells, and that well was not sampled. Significant organic groundwater contamination was indicated in the western portion of Site 4, in one monitoring well. Detections included VOCs (benzenes and total xylenes) in excess of State of Vermont Groundwater Quality Standards, and a TPH concentration in excess of 1 ppm. Possible inorganic groundwater contamination was indicated in the western and eastern portions of Site 4, and included: detections of lead in two wells in excess of the State of Vermont Groundwater Quality Standards, a detection of arsenic in one well in excess of the Groundwater Quality Standard, and a detection of chromium in one well in excess of the State of Vermont Quality Standard.

Hydrogeologic and analytical data indicate probable off-base migration of Site 4 groundwater contamination. Groundwater is apparently migrating to the northeast, across the base boundary and Poor Farm Road toward privately owned property (the Griswold property).

Surface Water and Sediments

Organic surface water and sediment contamination is present in the open drainage ditch in the eastern portion of Site 4. Organic contamination was limited to detections of TPH in the ppm range in the one surface water sample and in all three surface sediment samples.

7.0 RECOMMENDATIONS

The conclusions based on the results of ASI field investigation activities conducted at IRP Sites 3 and 4, support the following recommendations.

- Groundwater is the primary contamination concern in both Sites 3 and 4. The most significant soil contamination is located at or proximal to (within 5 ft) the water table in both sites. Additional ASI field screening and confirmation activities should be conducted to determine the horizontal extent, particularly the off-base extent, of free-product and dissolved-phase groundwater contamination. The results of these activities will enable development of the interim remedial actions listed below.
 - Interim remedial actions should be developed and implemented to intercept the off-base migration of dissolved-phase organic (and possibly inorganic) groundwater contamination.
 - Interim remedial actions should also be developed and implemented to abate the extent of free-product in Sites 3 and 4 and prevent its off-base migration in the vicinity of Site 4 and Poor Farm Road.
- Longer term remedial actions for Sites 3 and 4 should be focused on areas of free-product and groundwater contamination, particularly source areas and off-base areas.
- Remedial actions regarding shallow to intermediate subsurface soil contamination (above depths proximal to the water table), if required, should be limited to the Site 3 dry well and pump house (Building 205) in Site 3 source area, and possibly the original excavation area in the Site 4 source area.
- In conjunction with selected remedial actions, additional data may be developed to enable 1) further delineation of the nature and extent of on-base and off-base soil and groundwater contamination (vertical and horizontal extent) and 2) further characterization of the local geologic and hydrogeologic conditions.

8.0 BIBLIOGRAPHY

- CH₂MHill Southeast, Incorporated (CH₂MHill 1983), "Installation Restoration Program, Records Search, 158th Tactical Fighter Group, Vermont Air National Guard, Burlington International Airport," prepared for the Air National Guard Support Center, Andrews Air Force Base, Maryland.
- Connally, G.G. and Calkin, P.E. (Connally and Calkin 1972), "Woodfordian Glacial History of the Champlain Lowland, Burlington to Brandon, Vermont," Doolan, B.L. and Stanley, R.S., editors, Guidebook, New England Inter. Geol. Conf., 64th Annual Mtg., trip G-6, pp. 389-397, 1972.
- Doll, C.G., et al (Doll, et al 1961), "Centennial Geologic Map of Vermont," Vermont Geological Survey, scale 1:250,000, 1961.
- EARTH TECH (1994a), "Final Supplemental Remedial Investigation Work Plan, Vermont Air National Guard Base, Burlington, Vermont," prepared for the Hazardous Waste Remedial Actions Program (HAZWRAP), August 1994.
- EARTH TECH (1994b), "Final Abbreviated Site Investigation Work Plan, Vermont Air National Guard Base, Burlington, Vermont," prepared for HAZWRAP, August 1994.
- EARTH TECH (1994c), "Final Supplemental Remedial Investigation Sampling and Analysis Plan, Vermont Air National Guard Base, Burlington, Vermont," prepared for HAZWRAP, August 1994.
- Earth Technology (1991), "Installation Restoration Program Remedial Investigation/Feasibility Study, Final Technical Report, Vermont Air National Guard Base, Burlington International Airport," prepared for the United States Air Force, Brooks Air Force Base, Texas, May 1991.
- Geological Society of America (GSA 1991), "Rock-Color Chart, with Genuine Munsell® Color Chips, " 7th Printing, 1991.
- Hazardous Waste Remedial Actions Program (DOE/HWP-65RI 1990a), "Requirements for Quality Control of Analytical Data," DOE/HWP-65RI, July 1990.
- Hazardous Waste Remedial actions Program (DOE/HWP-69RI 1990b), "Quality Control Requirements for Field Methods," DOE/HWP-69RI, July 1990.
- Munsell® Soil Color Charts (Munsell® 1990), 1990 Edition Revised, Munsell® Color, Macbeth Division of Koll Morgan Instruments Corporation, Baltimore, Maryland.

- National Oceanic and Atmospheric Administration (NOAA 1987), "1987 Local Climatological Data, Annual Summary with Comparative Data, Burlington, Vermont," National Climatic Data Center, Asheville, North Carolina, 1988.
- State of California (California 1988), "Leaking Underground Fuel Tank Field Manual," State of California Water Resources Board, May 1988.
- State of Vermont (Vermont 1987), "Vermont Groundwater Protection Law," State of Vermont Agency of Environmental Conservation, Department of Water Resources and Environmental Engineering, 1987, published by The Bureau of National Affairs, Incorporated, Washington, D.C., October 21, 1990.
- State of Vermont (Vermont 1988), Chapter 12, Ground Water Protection Rule and Strategy," State of Vermont Agency of Natural Resources, Department of Environmental Conservation, Rule Number 88-37, September 29, 1988.
- State of Vermont (Vermont 1992a), "Interim Soil Cleanup Guidance," Vermont Department of Environmental Conservation, Hazardous Materials Management Division, Revised June 29, 1992.
- State of Vermont (Vermont 1992b), "Vermont Water Pollution Control Law," State of Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Quality Division, 1992, published by The Bureau of National Affairs, Incorporated, Washington, D.C., October 23, 1992.
- Stewart (1973), "Geology for Environmental Planning in the Burlington-Middlebury Region, Vermont," Vermont Geological Survey, Water Resources Department, Studies in Environmental Geology, Number 3, 45 p., 1973
- Stewart and MacClintock (1969), "Surficial Geology and Pleistocene History of Vermont," Vermont Geological Survey Bulletin, Number 31, 251 p. 1969.
- Telecon (1995a), Personal Communication, Teleconference between EARTH TECH, and Vermont HMMD, July 11, 1995.
- Telecon (1995b), Personal Communication, Teleconference between EARTH TECH, HAZWRAP, Vermont ANG, and Vermont HMMD, April 11, 1995.
- United States Department of Agriculture (USDA 1989), "Soil Survey of Chittenden County, Vermont," USDA Soil Conservation Service in cooperation with Vermont Agricultural Experiment Station and Vermont Department of Forests and Parks, Reissued January 1989.

United States (Department of The Interior) Geological Survey (USGS, 1987), "Burlington Quadrangle, Vermont - Chittenden County, 7.5 Minute Series (Topographic)," No. 44073-D2-TF-024, 1987.

United States Environmental Protection Agency (EPA 1986), "Test Methods for Evaluating Solid waste - Physical/Chemical Methods, " EPA SW-846, 3rd Edition, November 1986.

United States Environmental Protection Agency (EPA 1987), "Data Quality Objectives for Remedial Response Activities Development Process," Office of Solid Waste and Emergency Response Directive 93550-7B, March 1987.

United States Environmental Protection Agency (EPA 1990a), "EPA Contract Laboratory Program, Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration, March 1990 Revision.

United States Environmental Protection Agency (EPA 1990b), "EPA Contract Laboratory Program, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, March 1990 Revision.

United States Environmental Protection Agency (EPA 1991), "Toxicity Characteristic, " in Code of Federal Regulations Number 40 - Protection of the Environment, Part 261.24, June 1991.

United States Environmental Protection Agency (EPA 1992), "EPA Contract Laboratory Program, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, October 1992 Revision.

Weston, Roy, F., Incorporated (Weston 1986), "Installation Restoration Program, Phase II - Confirmation/Quantification, Stage 1, Final Report, Vermont Air National Guard, Burlington Air National Guard Base, Burlington, Vermont," prepared for the Air National Guard, Andrews Air Force Base, Maryland, March 1986.